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Quality Restoration Plan and Total Maximum Loads (TMDLs) for the Lake Helena Watershed Planning Area

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Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area:

Volume I – Appendices

December 30, 2004

Prepared for the Montana Department of Environmental Quality

Prepared by the U.S. Environmental Protection Agency, Montana Operations Office
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Appendix A: Lake Helena Watershed Characterization

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WATERSHED CHARACTERIZATION

The intent of this Appendix is to put Lake Helena and its tributaries into context with the watershed in which they occur. This section provides the reader with a general understanding of the environmental characteristics of the watershed that may have relevance to the 303(d) listed water quality impairments. This section also provides some detail regarding those characteristics of the watershed that may play a significant role in pollutant loading (e.g., geographical distribution of soil types, vegetative cover, land use).

A.1 Physical Characteristics

The following sections of the document describe the physical characteristics of the watershed, such as its location, climate, hydrologic features, and land use/land cover.

A.1.1 Location

The Lake Helena watershed is located in west-central Montana, encompassing an area of nearly 620 square miles (Figure A-1, Figure A-2). The watershed is bounded by the Continental Divide on the west, and by the Elkhorn Mountains located to the southeast. In general, the streams exhibit a dendritic pattern, flowing towards Lake Helena and the Missouri River in the northeastern part of the watershed. The three major drainages of the watershed include Silver, Tenmile and Prickly Pear creeks. Major tributaries include Sevenmile Creek (Tenmile drainage), and Warm Springs Creek, Lump Gulch, Clancy Creek, and McClellan Creek. (Prickly Pear drainage). The mountainous areas of the watershed are part of the Northern Rockies ecoregion while the Helena Valley area surrounding Lake Helena is part of the Montana Valley and Foothill Prairies ecoregion (Omernik, 1987). Approximately 68 percent of the watershed is located within Lewis and Clark County, and the remaining 32 percent lies within Jefferson County (Figure A-3). Montana's capitol city, Helena, is located near the center of the watershed.

The average elevation in the watershed is 5,085 feet. Elkhorn Peak is the highest point, with an elevation of 9,379 feet above mean sea level. The minimum elevation is 3,654 feet at the surface of Lake Helena. The watershed is part of the Upper Missouri Watershed (USGS 8-digit hydrologic cataloging unit number 10030101) and includes the following 4th-field code identifiers: 120, 130, 140, and 150.

Figure A-1. City of Helena and the Lake Helena watershed.

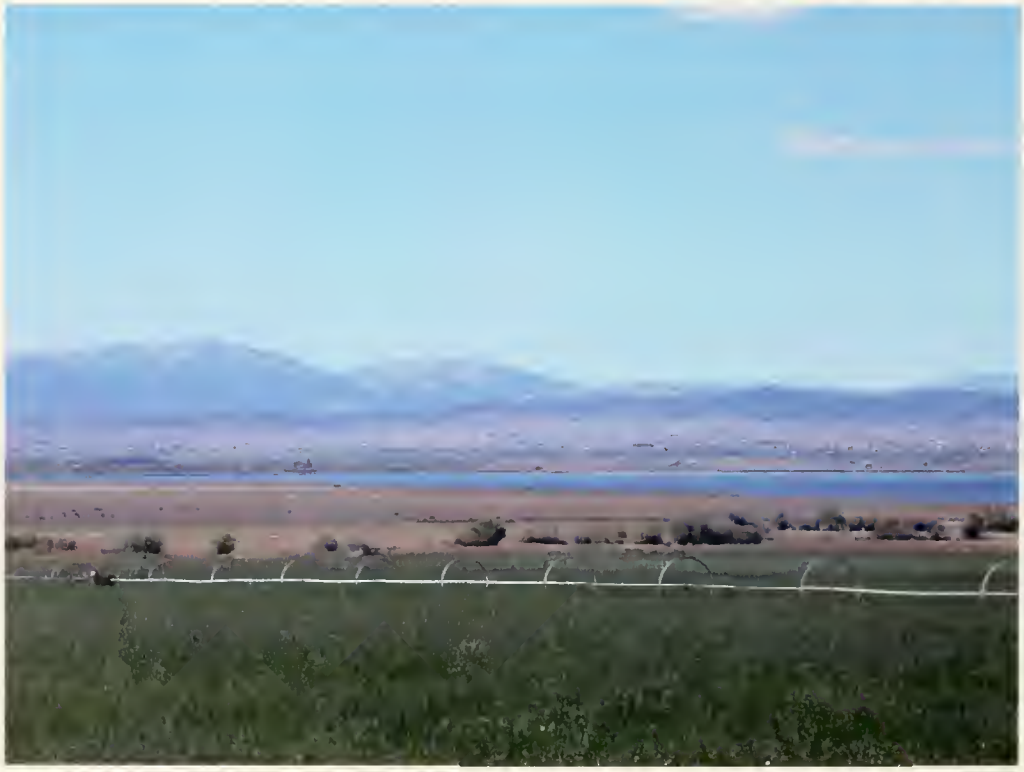


Figure A-2. Lake Helena and the Lake Helena Valley.

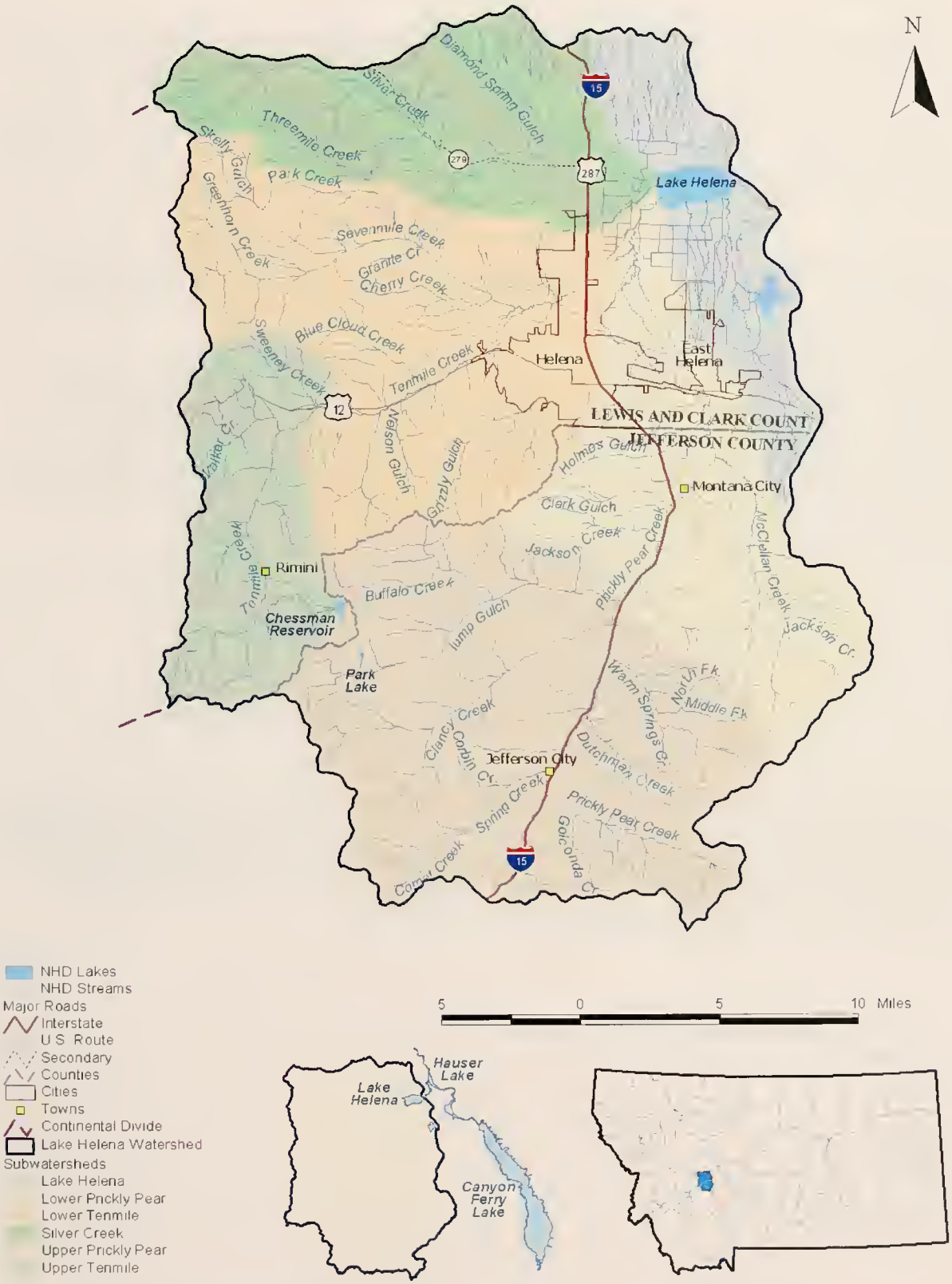


Figure A-3. Location of the Lake Helena watershed.

A.1.2 Climate

Climate in the Lake Helena watershed is classified as modified continental. It is characterized by cold weather from November through February, with temperatures dropping to zero and below (Fahrenheit), and moderate temperatures in the summer, with measurements typically under 90 degrees and rarely reaching 100 degrees. Temperatures fluctuate significantly from day to night. Most of the precipitation occurs from April through July, and June is generally the wettest month of the year. Precipitation occurs primarily as winter snow and spring rains. Summer, fall, and winter months are relatively dry, but from April to September precipitation varies greatly. Snowfall occurs from September through May.

The National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC) stores and distributes weather data gathered by the Cooperative Observer Network (COOP) throughout the United States. There are three active weather stations located in the Lake Helena watershed as shown in Figure A-4 and listed in Table A-1.
Figure A-5 illustrates average maximum and minimum temperatures, and Figure A-6 shows average precipitation throughout the year for the Helena WSO station (NOAA Cooperative station number 244055-4). Likewise, Figure A-7 and Figure A-8 show average maximum and minimum temperatures and average precipitation, respectively, throughout the year for the Austin 1 W station (NOAA Cooperative station number 240375). The Helena station is located in the valley region of the watershed at an elevation of 3,830 feet and the Austin station is located at a higher elevation of 4,790 feet in a more mountainous region.

Table A-1. Active NOAA climate stations in the Lake Helena watershed.

Station Name	Coop-ID	Elevation (ft)
Austin 1 W	240375-4	4,790
Helena WSO	244055-4	3,830
Rimini 4 NE	247055-4	4,700

Total annual average precipitation and annual average snowfall at the Helena station are 11.8 inches and 50.3 inches, respectively. Average temperatures at this station range from a maximum of 83.8 °F in July to a minimum of 11.1 °F in January. At the Austin station, total annual average precipitation is 15.9 inches and annual average snowfall is 62.8 inches. Average temperatures at this station range from a maximum of 81.1 °F in July to a minimum of 11.3 °F in January.

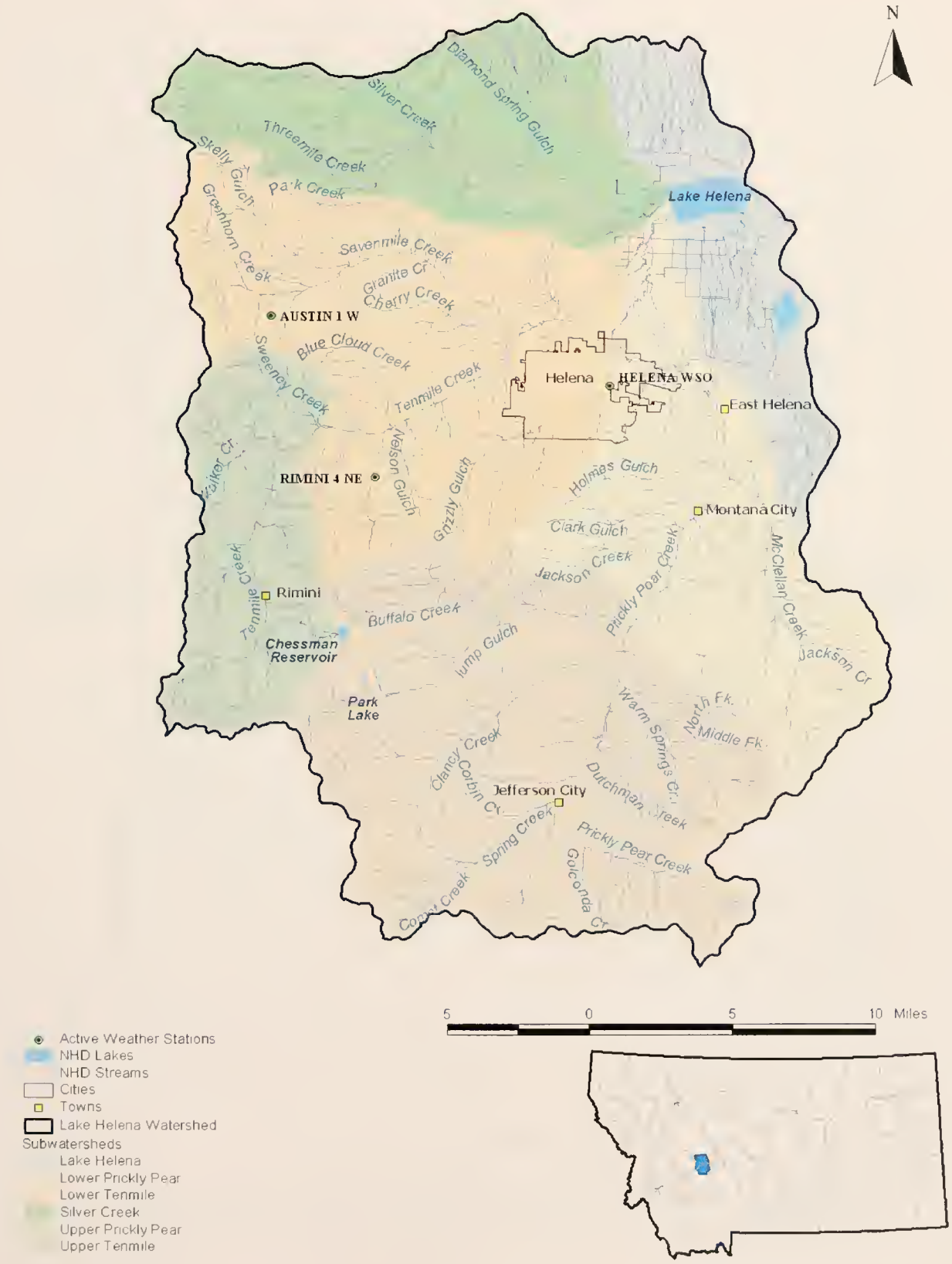


Figure A-4. Location of climate stations in the Lake Helena watershed.

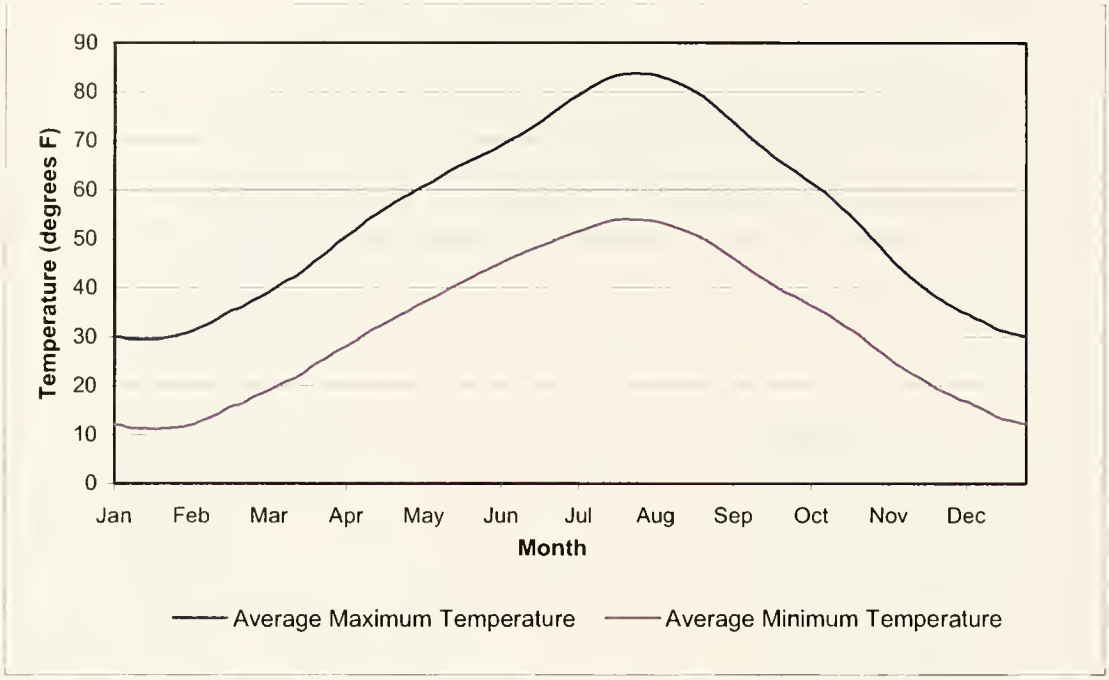


Figure A-5. Average maximum and minimum temperatures for Helena WSO, MT, Station 244055.

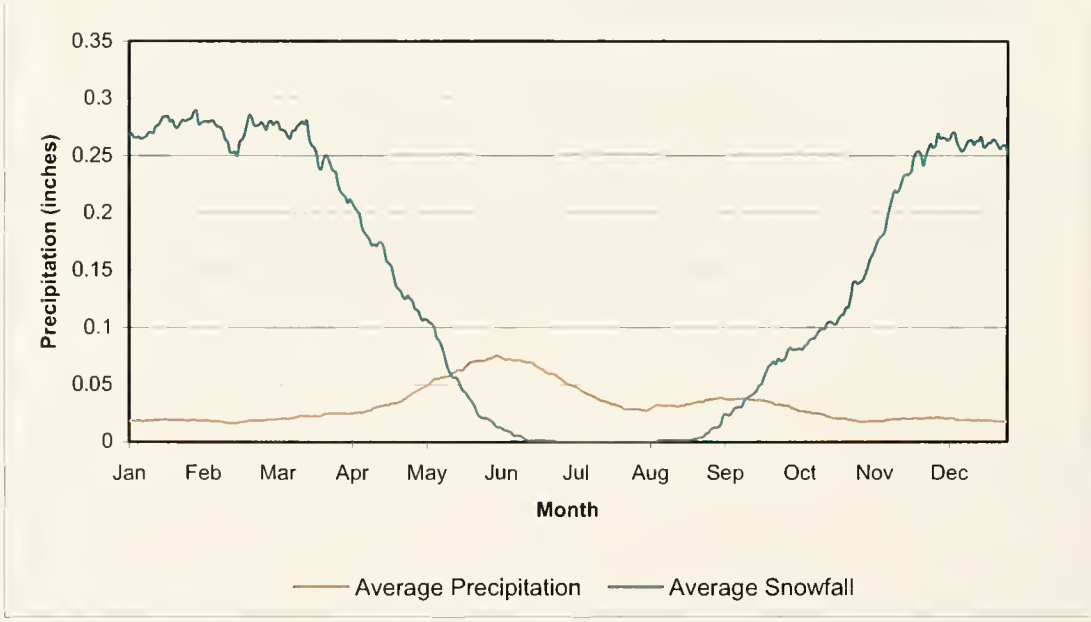


Figure A-6. Average precipitation for Helena WSO, MT, Station 244055.

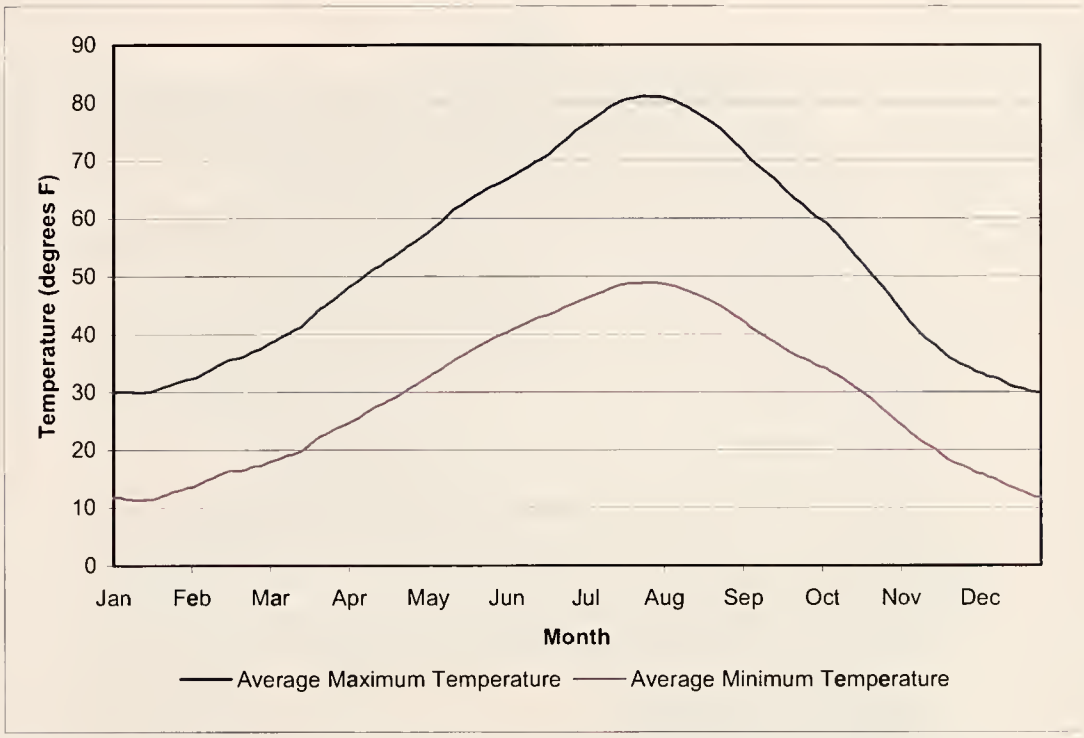


Figure A-7. Average maximum and minimum temperatures for Austin 1 W, MT, Station 240375.

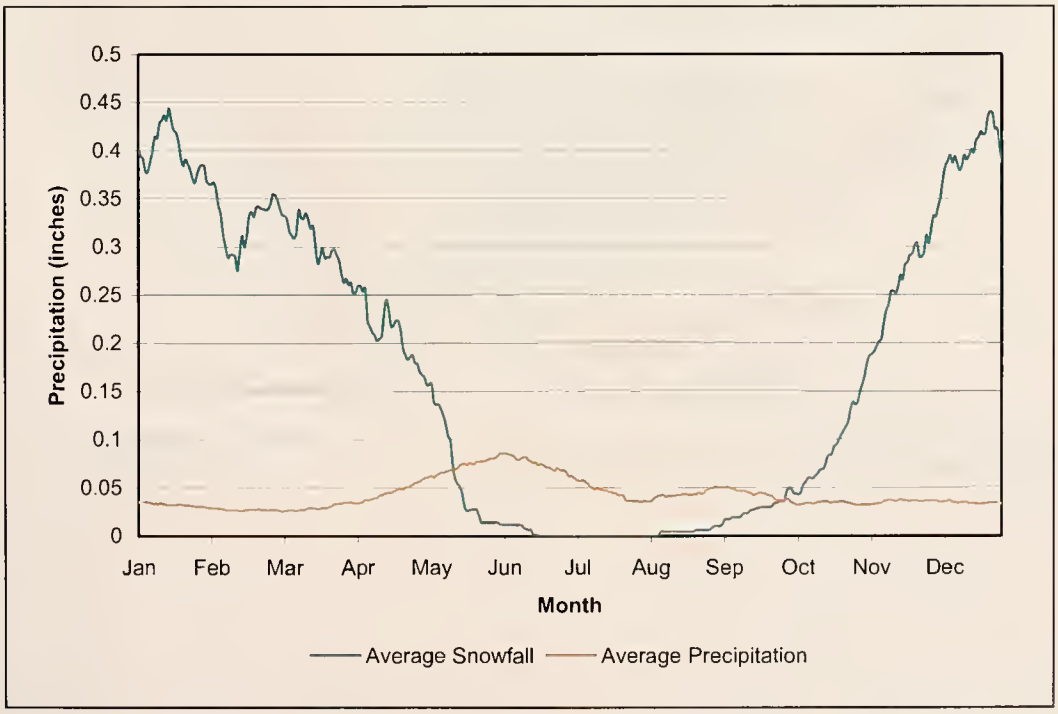


Figure A-8. Average precipitation for Austin 1 W, MT, Station 240375.

A.1.3 Topography

Figure A-9 displays the general topography within the Lake Helena watershed, and a shaded relief map of the watershed is presented in Figure A-10. As seen in Figure A-9, elevations are highest in the southern and western portions of the watershed and range from 6,000 to 9,338 feet above mean sea level. The watershed's highest point, Elkhorn Peak, is located in the southeastern corner. The lowest elevations are found in the northeastern part of the watershed in the Helena Valley surrounding Lake Helena, where elevation reaches a minimum of 3,654 feet above mean sea level. The average elevation in the watershed is 5,085 feet.

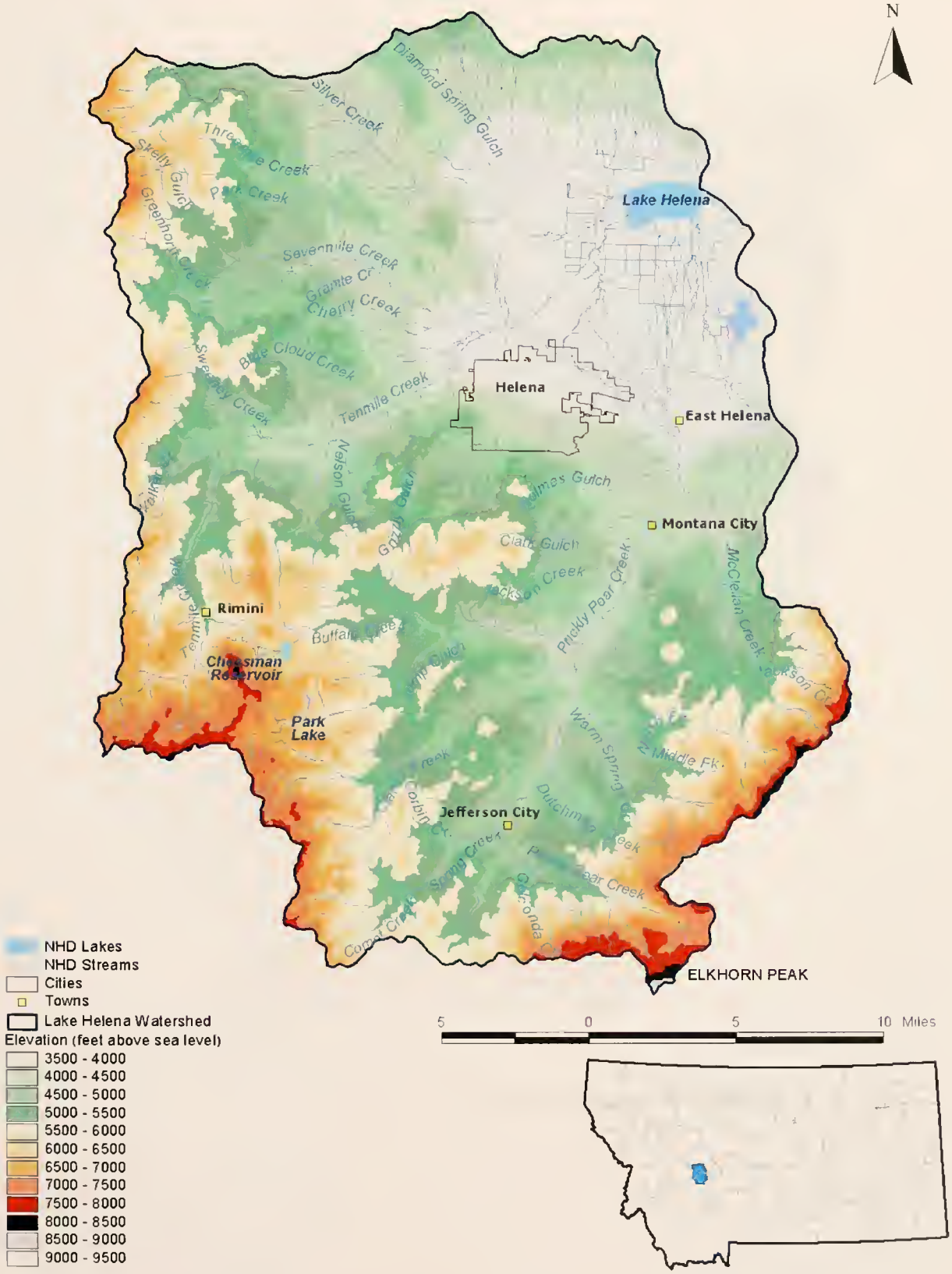


Figure A-9. Elevation in the Lake Helena watershed.

Figure A-10. Shaded relief map of the Lake Helena watershed.

A.1.4 Soils

Soils data and GIS coverages from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the Lake Helena watershed. General soils data and map unit delineations for the United States are provided as part of the State Soil Geographic (STATSGO) database. GIS coverages provide accurate locations for the soil map units (MUIDs) at a scale of 1:250,000 (USDA, 1995). A map unit is composed of several soil series having similar properties. Identification fields in the GIS coverages can be linked to the database that provides information on chemical and physical soil characteristics. Figure A-11 shows the general map unit boundaries in the Lake Helena watershed, and the following sections summarize relevant soils data.

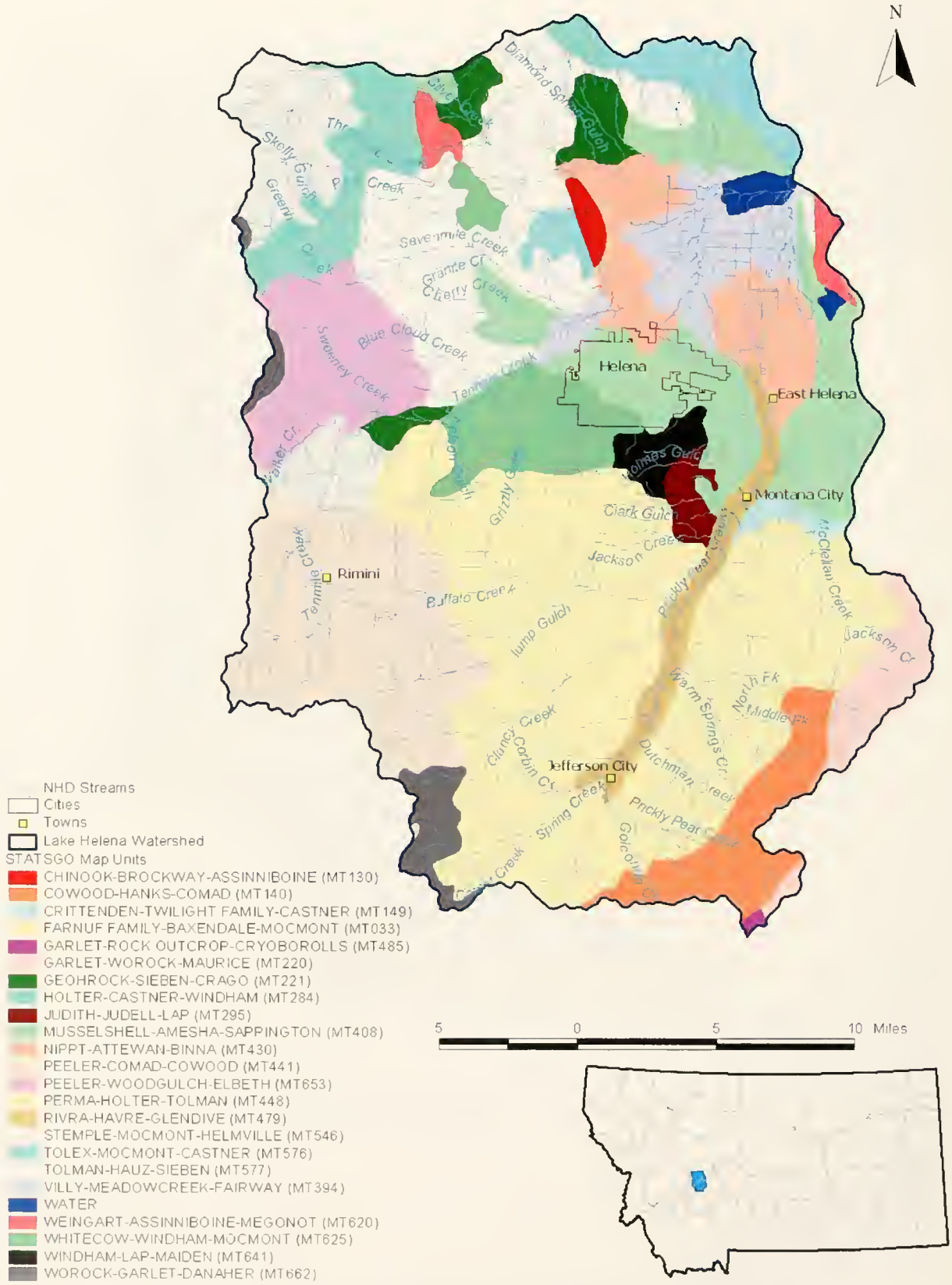


Figure A-11. General soil units in the Lake Helena watershed.

A.1.5 Universal Soil Loss Equation (USLE) K-factor

A commonly used soil attribute is the K-factor, which is a component of the Universal Soil Loss Equation (Wischmeier and Smith, 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion, and factor values may range from 0 for water surfaces to 1.00. In practice, maximum factor values generally do not exceed 0.67. Large K-factor values reflect greater inherent soil erodibility. The distribution of K-factor values in the Lake Helena watershed is shown in Figure A-12. The figure indicates that, on average, all of the soils in the watershed have K-factors ranging from 0.1 to 0.36, suggesting moderate soil erosion potential. The figure also shows that the potential for erosion is greater in the soils of the Helena Valley than in the soils of the headwaters. Actual erosion is influenced by other factors, including rainfall and runoff, land slope, vegetation cover, and land management practices.

A.1.6 Hydrologic Soil Group

NRCS has defined four hydrologic soil groups (Table A-2). The hydrologic soil group classification is a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have the worst infiltration rates, while sandy soils that are well drained have the best infiltration rates. Data for the Lake Helena watershed were obtained from STATSGO (NRCS, 2001). The data were summarized based on the major hydrologic group in the surface layers of the map unit and are displayed in Figure A-13. Soils in the Lake Helena watershed are classified as B and C, described as having moderate to slow infiltration rates when saturated.

Table A-2. Hydrologic soils group descriptions.

Hydrologic Soils Group	Description
A	Soils with high infiltrations rates. Usually deep, well drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.

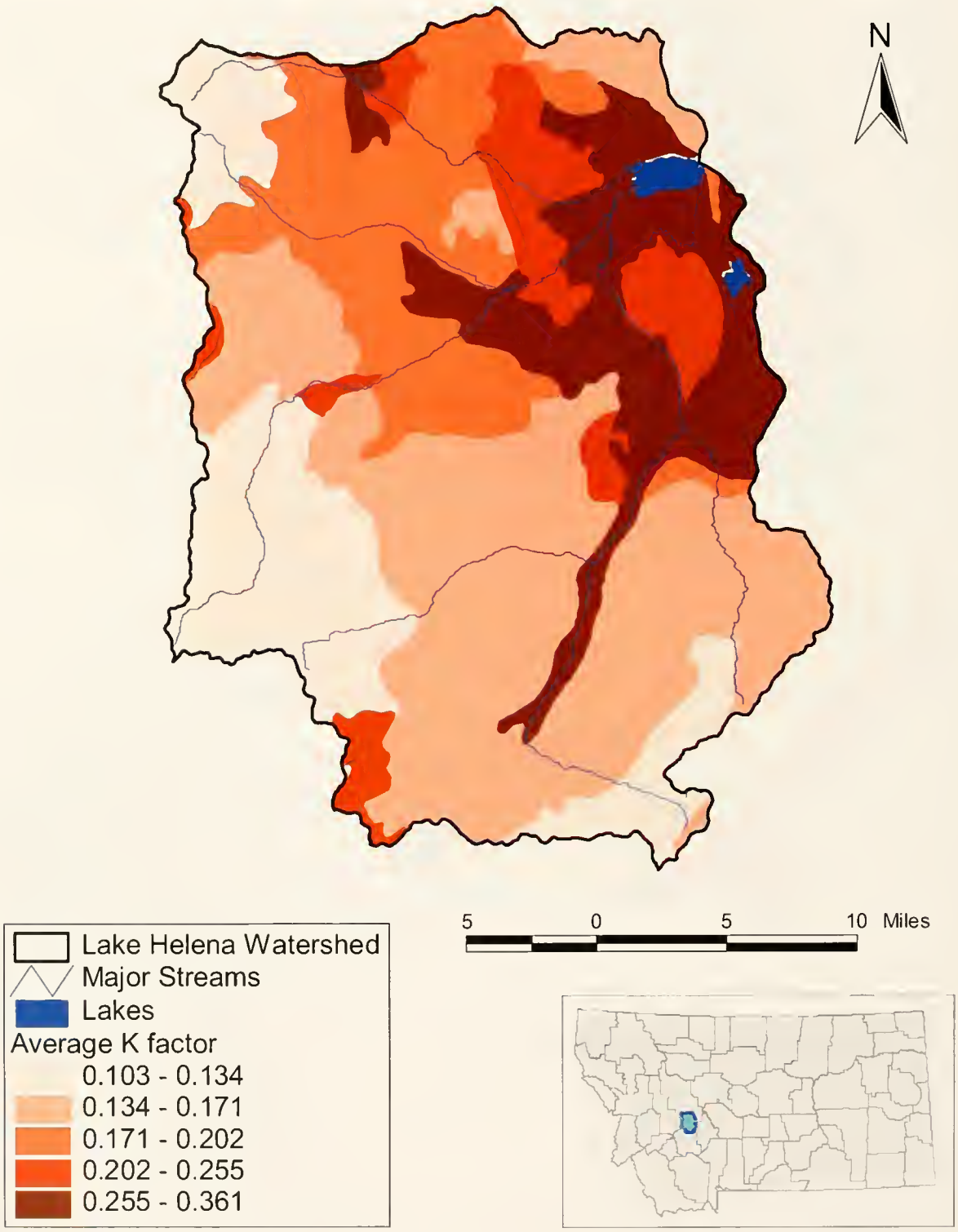


Figure A-12. Distribution of the USLE K-factor in the Lake Helena watershed.

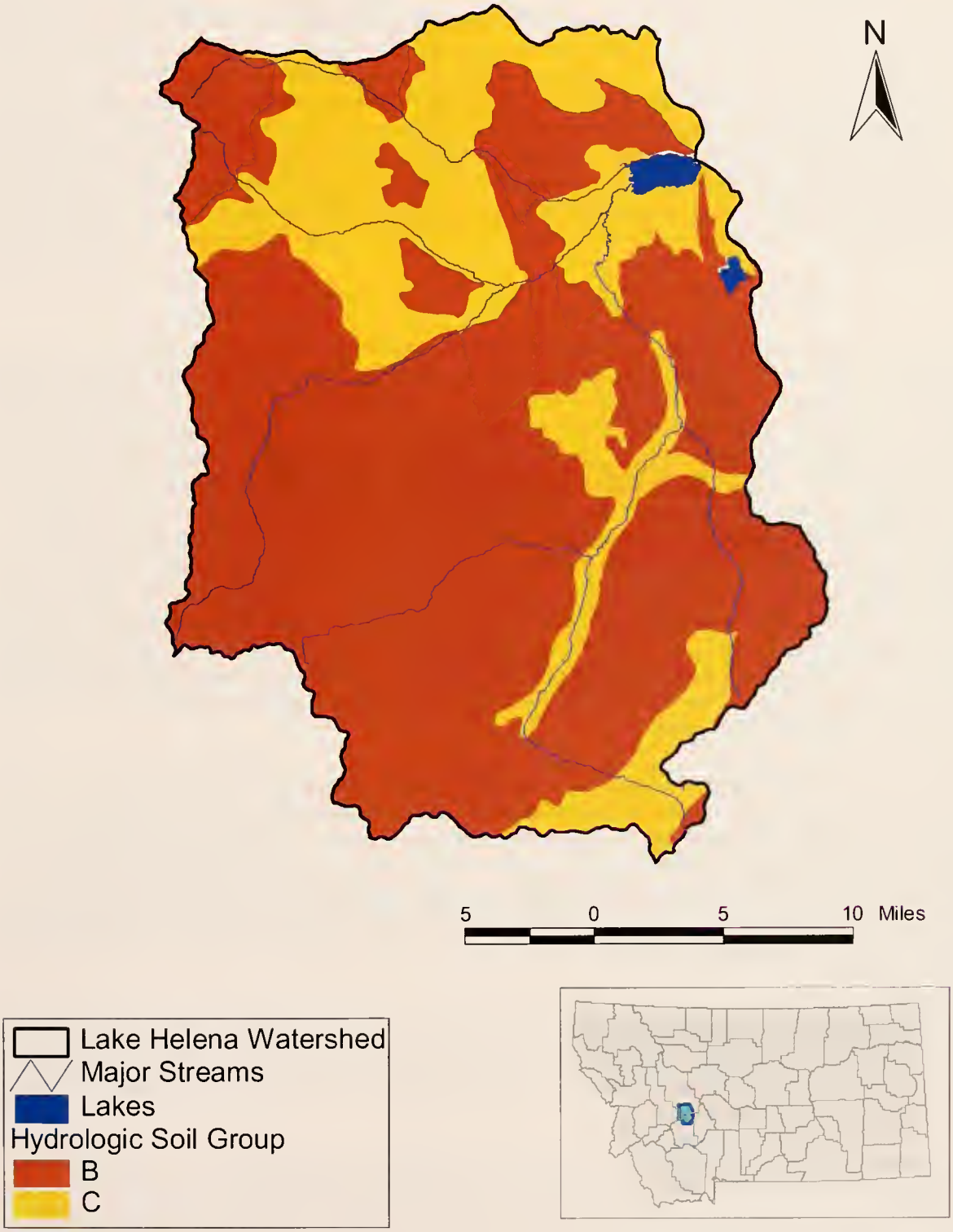


Figure A-13. Distribution of hydrologic soil groups in the Lake Helena watershed.

A.1.7 Hydrology

Surface water enters the Helena Valley principally from Prickly Pear Creek, Tenmile Creek, Silver Creek, and from irrigation water that is diverted from the Missouri River. Diversions from the Missouri River to the Helena Valley via the Helena Valley Regulating Reservoir account for an average of about 87,000 acre-feet per year of additional inflow into the watershed. The Helena Valley Irrigation District uses most of this volume of water for irrigation, while the City of Helena uses up to 5,680 acre-feet of water per year water from the regulating reservoir for municipal and industrial purposes. The City of Helena is proposing to increase its use of Missouri River water to 11,300 acre-feet/year and the Helena Valley Irrigation District is proposing to expand its irrigated acreage from 15,608 acres to about 18,200 acres (USBR, 2004).

A.1.8 Water Bodies

The reservoirs and streams within the Lake Helena watershed are shown in Figure A-14. Most surface water in the Helena Valley flows towards Lake Helena. The principal surface and groundwater discharge point is Lake Helena (Kendy et al., 1998). Lake Helena is a shallow water body at the base of the Helena Valley. The surface area is approximately 3.2 square miles, or 2,072 acres. The water elevation of Lake Helena is partly controlled by Hauser Lake, a reservoir located to the north and east of Lake Helena on the Missouri River. When Hauser Dam was constructed on the Missouri River, the wetlands in the lower reaches of Silver and Prickly Pear creeks were flooded which created Lake Helena. Hauser Lake was impounded in 1907, and an earthen causeway and control mechanisms were constructed in 1945 to separate Hauser Lake and Lake Helena, allowing the two to be regulated independently. The level of Hauser Lake is controlled for power generation, and the flow between the two reservoirs depends on the level of Lake Helena relative to that of Hauser Lake. Net flow between the two reservoirs is from Lake Helena to Hauser Lake, but flow frequently reverses (Shields, et. al., 1995). In 1912, the Montana Reservoir and Irrigation Company erected pumping plants on the north and south shores of Lake Helena for an irrigation system to serve the valley. The company operated the pumps and delivered water until the late 1940s (Kendy et al., 1998).

Major tributaries discharging to Lake Helena include Prickly Pear Creek, Tenmile Creek, Silver Creek and their tributaries. Lake Helena also receives inflow from irrigation tile drains on the south, west and north and, seasonally, from the Helena Valley Irrigation Canal on the west and from the Missouri River (Hauser Lake) backwater on the east (Kendy et al., 1998). The Silver Creek drainage is intermittent where it enters the Helena Valley and its channel has been relocated as a result of development activities. Silver Creek flows from west to east across the Helena Valley as a constructed ditch and most of its flow where it enters Lake Helena consists of groundwater tile drainage from the west and north portions of the Helena Valley.

Individual domestic and community water supply wells are present in shallow aquifers of the valley and are partially recharged by infiltrated irrigation water and septic systems, both of which can affect the quality of the water in the shallow aquifer. Some of the irrigation water returns as surface drainage to Lake Helena (Kendy et al., 1998).

The Helena Valley Irrigation District contracts with the Bureau of Reclamation for water for agricultural irrigation, and the City of Helena contracts water for municipal and industrial uses. The water is delivered from Canyon Ferry Reservoir through the Helena Valley pumping plant, tunnel and feeder canal. The water is stored in the Helena Valley Regulating Reservoir and made available to meet the demands of the irrigation district and the city (USBR, 2004). The City withdraws its water from the regulating reservoir by a pipeline to the Missouri River treatment plant. The Helena Valley Canal distributes water from the regulating reservoir. This canal, show in Figure A-14 and Figure A-15, nearly

encircles the Helena Valley alluvial plain, and water is distributed to the central part of the Helena Valley through an extensive network of lateral canals (USGS, 2001). The Helena Valley Regulating Reservoir, located 3.5 miles west of Canyon Ferry Dam on the Missouri River, can store up to 10,451 acre-ft of water.

Other impoundments in the Lake Helena watershed include Chessman and Scott reservoirs, which are part of the City of Helena's water supply storage and delivery system. These water bodies are located west of Helena in the Tenmile drainage near the Town of Rimini. Chessman and Scott reservoirs are filled every spring with runoff diverted from several small streams via a flume system. Stored water is then released on a seasonal basis to augment flows in Tenmile Creek upstream from diversions to the City's Tenmile Water Treatment Plant (Cleasby and Nimmick, 2002; City of Helena Public Works Department, 2002).

Figure A-14. Water bodies within the Lake Helena watershed.

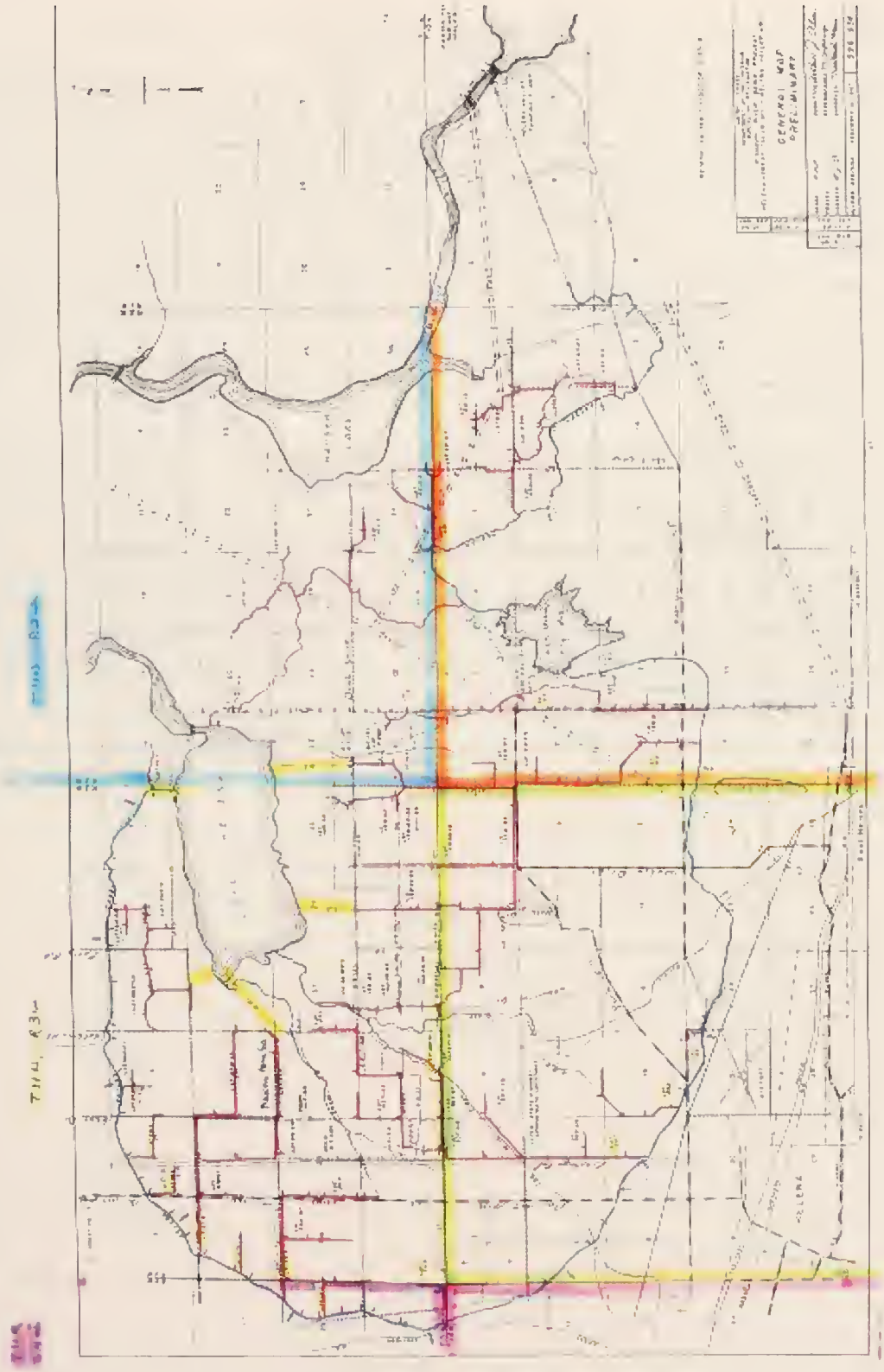


Figure A-15. Lake Helena, Helena Valley irrigation canals, and regulating reservoir (source: Helena Valley Irrigation District).

A.1.9 Flow Data

Streamflow varies from site to site and seasonally in the Helena Valley as a result of complex patterns of precipitation and runoff, groundwater and surface water interactions, and water diversions and storage. Flow increases in streams are attributed to tributary inflows or groundwater discharge, and flow depletions occur as a result of irrigation diversions and water losses to groundwater (USGS, 2001). A series of tile drains were installed throughout much of the Helena Valley during the late 1950s. The drainage system has lowered the elevation of the shallow aquifer, drained numerous acres of historic wetlands, caused the loss of natural infiltration and groundwater recharge areas, and reduced surface flows in lower Tenmile, Prickly Pear, and possibly Silver creeks. The tile drains discharge directly into Lake Helena as a series of canals. Property owners and residents along Tenmile, Sevenmile, and Prickly Pear Creeks and in other low lying areas of the watershed have routinely experienced damage to personal property due to floods associated with spring runoff and unpredictable winter thaws (Wetlands Community Partnership, 2001).

The USGS National Water Information System (NWIS) online database lists 17 streamflow gages in the Lake Helena watershed with current and historical flow data. Ten stations with recent flow data were analyzed to obtain a general understanding of flow patterns from the tributary headwaters to Lake Helena. These stations included McClellan Creek near East Helena, Prickly Pear Creek near Clancy, Prickly Pear Creek below Anderson Gulch near Jefferson City, Tenmile Creek above Prickly Pear Creek near Helena, Tenmile Creek at Green Meadow Drive at Helena, Tenmile Creek near Helena, Tenmile Creek at State Nursery Bridge near Helena, Tenmile Creek at Tenmile Water Treatment Plant near Rimini, Tenmile Creek near Rimini, and Sevenmile Creek below Granite Creek near Helena. The selected stations are described in Table A-3 and are shown in Figure A-16.

Table A-3. Selected USGS stream gages in the Lake Helena watershed.

		Drainage Area			
Station ID	Gage Name	Acres	Square Miles	Start Date	End Date
06061900	McClellan Creek near East Helena	21,248	33	Sep 1988	Sep 1990
06061500	Prickly Pear Creek near Clancy	122,880	192	Jul 1908	Sep 2001
06058900	Prickly Pear Creek below Anderson Gulch near Jefferson City	8,960	14	Oct 1988	Sep 1990
06064150	Tenmile Creek above Prickly Pear Creek near Helena	120,320	188	May 1997	Sep 1998
06064100	Tenmile Creek at Green Meadow Drive at Helena	103,040	161	May 1997	Sep 1998
06063000	Tenmile Creek near Helena	61,760	97	Aug 1908	Sep 1998
06062990	Tenmile Creek at State Nursery Bridge near Helena	N/A	N/A	Mar 1990	Aug 1992
06062750	Tenmile Creek at Tenmile Water Treatment Plant near Rimini	32,704	51	May 1997	Sep 2001
06062500	Tenmile Creek near Rimini	19,776	31	Oct 1914	Sep 2001
06063600	Sevenmile Creek below Granite Creek near Helena	N/A	N/A	Mar 1990	Sep 1991

Figure A-16. Location of selected USGS streamflow gages in the Lake Helena watershed.

The average daily streamflow measured at each of six of the ten selected stations during 1990 is displayed in Figure A-17 through Figure A-20. Flow patterns at most of the stations show peaks in late April and again in early June due to snowmelt runoff and precipitation. Figure A-17 shows average daily streamflow measured at two stations along Prickly Pear Creek. Flows are noticeably higher at the downstream station number 06061500, located in the middle portion of the drainage near Clancy, than at station number 06058900, which is located in the upper drainage near Jefferson City. This is due to the larger watershed drainage area at the former station and the influence of several incoming tributaries, including Warm Springs, Clancy and Lump Gulch creeks. This station also has the highest base flow of all the stations examined. Flow patterns at station 06061900 on McClellan Creek, a tributary to the middle reaches of Prickly Pear Creek, are similar to those seen at the other stations with peaks occurring in late April and early June (Figure A-19).

Daily mean streamflows at Tenmile Creek stations 06062500 (near Rimini) and 06062990 (State Nursery Bridge) are shown in Figure A-18. These stations have very similar seasonal flow patterns, although station 06062990 is located further downstream in the watershed and has a slightly higher flow on most occasions. The highest peak flows recorded in Tenmile Creek during 1990 were measured at station 06062990. Station 06063600 on Sevenmile Creek, a Tenmile Creek tributary, showed a moderate and less variable flow when compared to patterns seen at the other gaging stations (Figure A-20).

In general, flows in Lake Helena watershed streams are low and fairly constant from September through March. The highest flows can be expected during the months of April and June, and these are typically one to two orders magnitude greater than the baseflow levels.

At present, water diverted from upper Tenmile Creek provides 70 percent of the City of Helena's municipal water supply during the months of June through September, and 100 percent of the city's water supply from October through May. Diversions are located on Tenmile Creek south of Rimini and near the confluences of Beaver, Minnehaha, Moose, and Walker creeks. Additional water is obtained from Scott and Chessman reservoirs, which collect water from several tributaries during periods of high flow. This stored water is held in reserve and accessed on an as-needed basis (E^2 Inc. et al., 2004). Municipal water diversions often dewater portions of Tenmile Creek, particularly the reach from Rimini to the mouth of Spring Creek, a distance of 0.5 mile (USGS, 2000). Further downstream near the City of Helena, seasonal irrigation withdrawals contribute to the streamflow depletion problems leaving a dry streambed in some locations. In the lower three miles of Tenmile Creek upstream of its confluence with Prickly Pear Creek, flows may be supplemented at times with water from the Helena Valley Irrigation District. This additional water may enter lower Tenmile Creek in the form of direct spills, or as irrigation return flows from either surface or groundwater sources. In general, streamflows in lower Tenmile Creek tend to be unpredictable and highly variable from month to month, reflecting a complex pattern of runoff, groundwater and surface water interactions, and diversion management (USGS, 2001).

Silver Creek's hydrology has been altered as a result of placer mining and deposition of mill wastes in its upper watershed (Maxim, 1996). Further downstream, Silver Creek becomes intermittent due to irrigation diversions, channel alterations, and other hydrologic modifications. Silver Creek flows into Lake Helena as a constructed ditch and most of its flow at that location originates from groundwater tile drainage entering the ditch at various locations from the west and north portions of the Helena Valley.

Prickly Pear Creek is severely dewatered during the irrigation season beginning at a major diversion just below East Helena and continuing downstream to Lake Helena. Prickly Pear Creek and many of its tributary drainages, as well as the Tenmile and Silver Creek subwatersheds, have undergone many changes over the last 140 years. Extensive placer and lode mining, minerals smelting, agricultural development, timber harvest, road construction, livestock grazing, other land uses, and wildfires have

altered the natural hydrology of the Lake Helena watershed. These changes and their implications to water quality are discussed in more detail in Section 3.0 of this report.

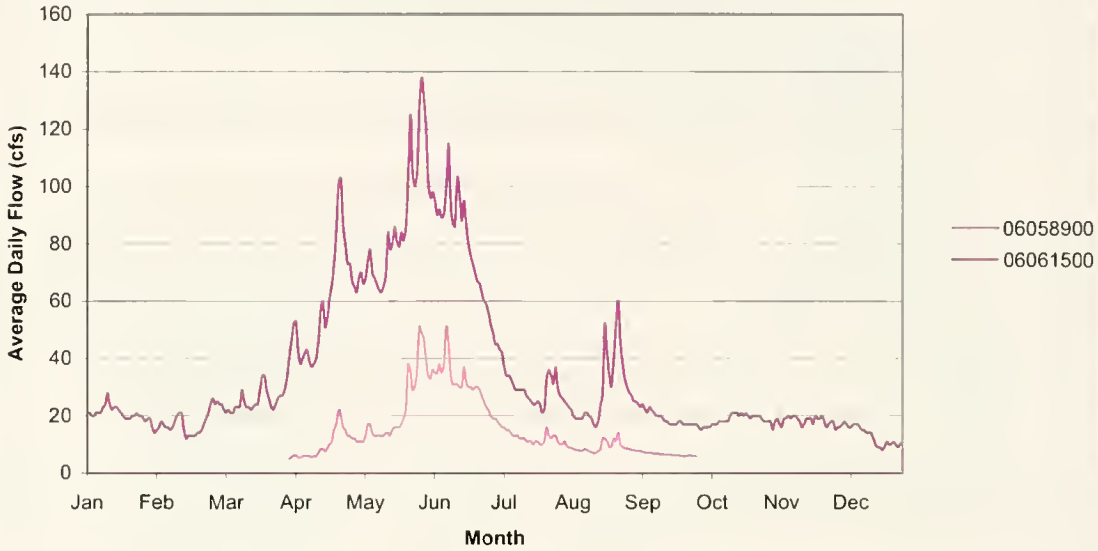


Figure A-17. Average daily flow for year 1990 at USGS gages 06058900 and 06061500 on Prickly Pear Creek.

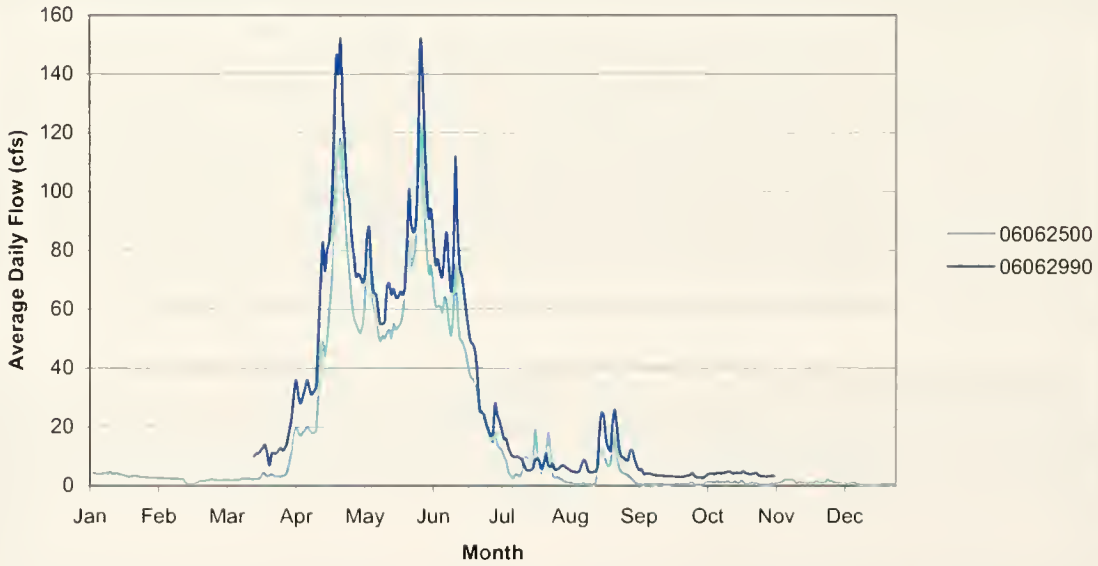


Figure A-18. Average daily flow for year 1990 at USGS gages 06062500 and 06062990 on Tenmile Creek.

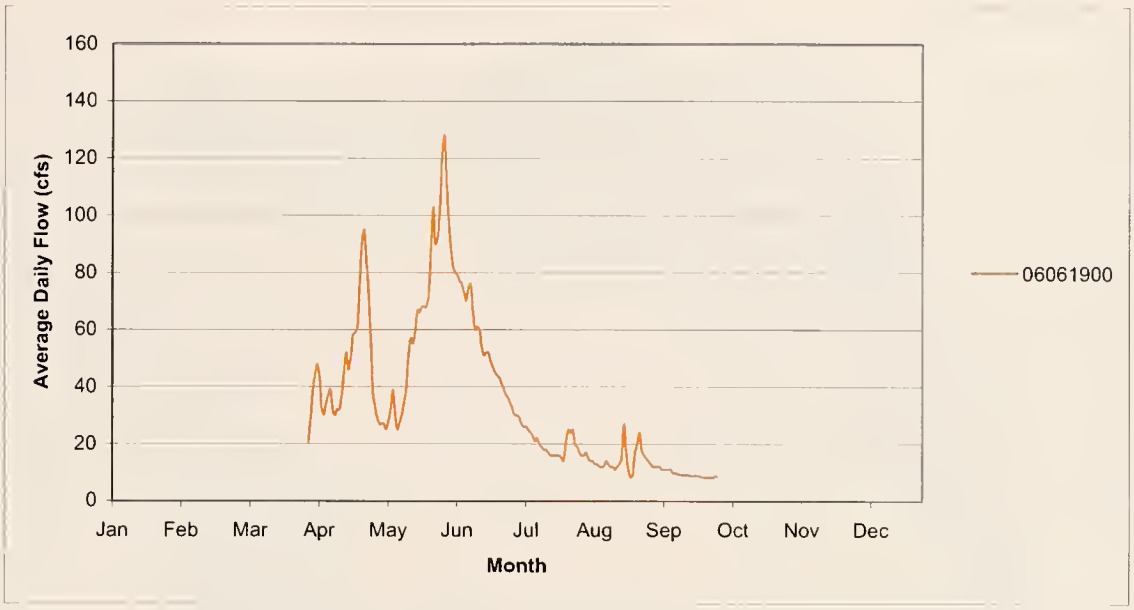


Figure A-19. Average daily flow for year 1990 at USGS station 06061900 on McClellan Creek.

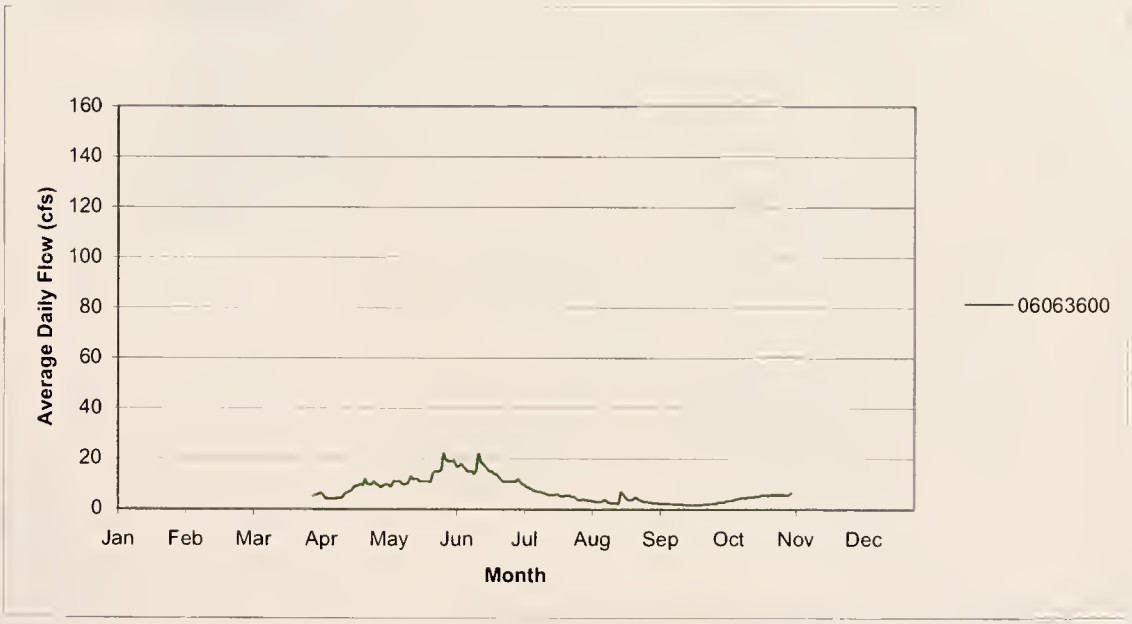


Figure A-20. Average daily flow for year 1990 at USGS gage 06063600 on Sevenmile Creek.

A.1.10 Stream Types

The Helena Valley is drained by a network of intermittent and perennial streams. Prickly Pear, Tenmile, and Silver creeks converge at Lake Helena, which drains into the Missouri River. The National Hydrography Dataset (NHD) provided by USEPA and USGS identified four major stream types in the Lake Helena watershed. Table A-4 and Figure A-21 present a summary of the stream types in the Lake Helena watershed. Most of the streams in the watershed were classified as either perennial (45%) or intermittent (44%). Other stream types include canals/ditches and pipelines. Intermittent streams have flow only for short periods during the course of a year, and flow events are usually initiated by rainfall. Perennial streams flow throughout the entire year. The main stem of the major tributaries and most headwater streams were classified as perennial. However, seasonal dewatering occurs in the lower sections of Silver, Tenmile, and Prickly Pear creeks as a result of irrigation withdrawals and losses to groundwater. Mountain streams of varying sizes have perennial flow due to snowmelt, precipitation, and discharge from bedrock aquifers, while many of the smaller tributaries located in the valley regions of the watershed are intermittent. All of the canals and ditches are concentrated in agricultural areas surrounding Lake Helena.

Table A-4. Summary of stream types in the Lake Helena watershed.

Stream Type	Stream Length (miles)	Percent
Perennial	426	45.4
Intermittent	418	44.5
Canal/Ditch	91	9.7
Pipeline	4	0.5
Total	940	100.0

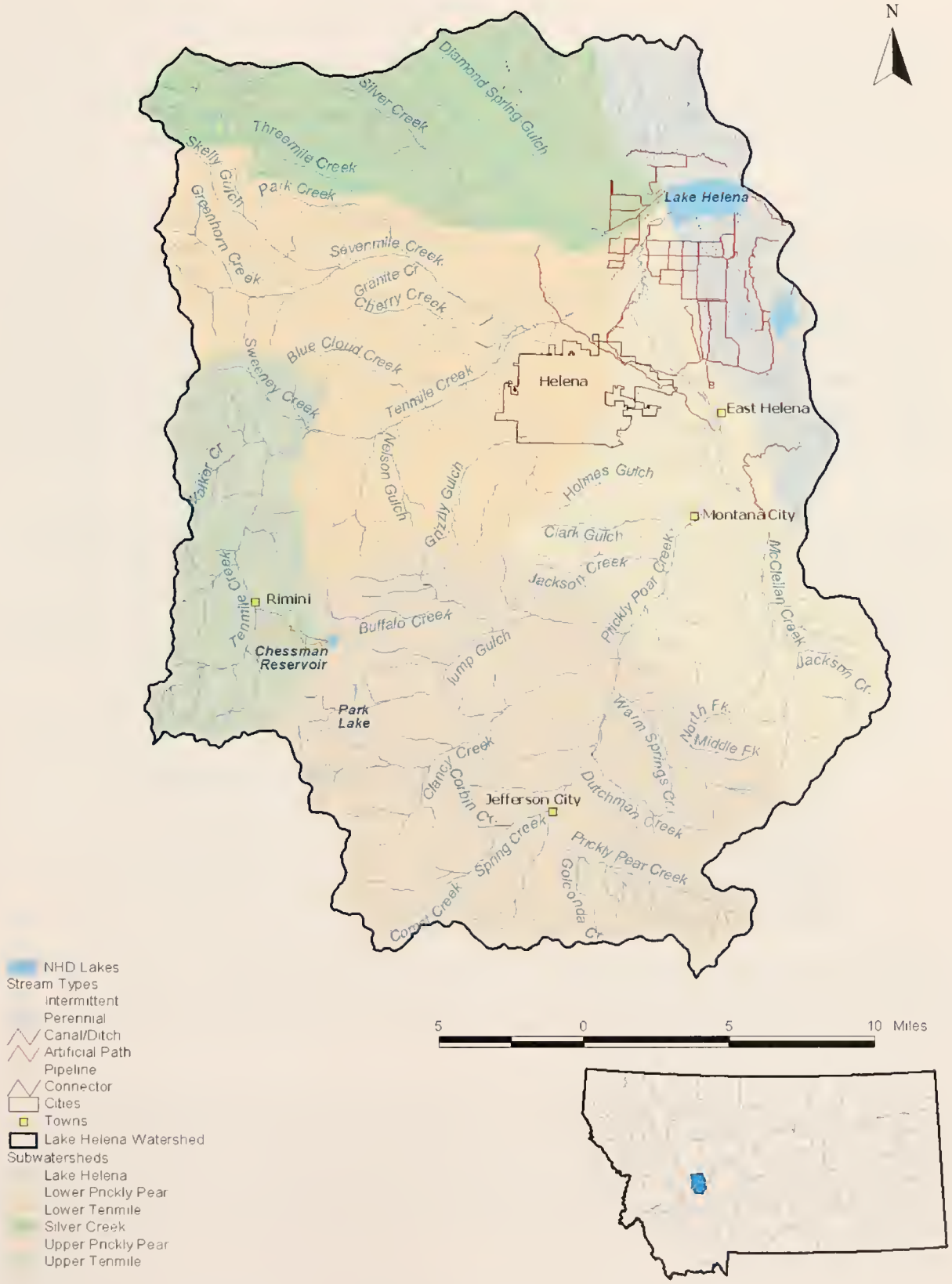


Figure A-21. Stream types in the Lake Helena watershed.

A.1.11 Groundwater

Groundwater in the Helena area is the sole source of drinking water for more than 27,000 people, approximately 55 percent of the area population. The Helena Valley alluvial aquifer provides water through approximately 5,600 domestic wells and 71 public water supplies (Lewis and Clark County, 2004).

A relatively high groundwater production capability exists in the central portion of the Helena Valley. In general, water supply wells in the central portion of the valley produce over 100 gallons per minute (gpm), while significantly lower groundwater production capacity (≤ 20 gpm) is common near the margins of the valley. Major surface water features such as Prickly Pear, Tenmile Creek, and Sevenmile creeks contribute water to some degree to the groundwater system. Water levels in general are less than 10 feet below the ground surface in the southwestern portion of the Helena Valley, and are closer to the surface in several areas. The presence of springs in the valley indicates groundwater discharge zones, and near-surface groundwater flows (Wetlands Community Partnership, 2002). Another factor influencing shallow groundwater elevations in the Helena Valley is the extensive network of tile drains, which have artificially lowered the water table.

The hills and mountains adjacent to the Helena Valley collect precipitation that eventually recharges aquifers in the Helena Valley. The recharge to the shallow aquifer system alluvial materials originates from infiltration of precipitation (rain and snow), irrigation water, and streamflow. Recharge from bedrock surrounding the valley contributes a significant amount of water to the Helena Valley. Approximately 44 percent of recharge to the valley is estimated to come from inflow from the underlying bedrock. Water migrates from the upper elevations surrounding the valley through fractures and joints towards the valley and stream drainages (Table A-5) (Wetlands Community Partnership, 2002).

Table A-5. Sources of Groundwater Recharge in the Helena Valley (Wetlands Community Partnership, 2002).

Source	Amount Acre feet/year	Percent
Infiltration-streamflow	2,900	14
Leakage-irrigation canal	7,060	8
Infiltration-excess irrigation	27,000	30
Infiltration-precipitation	---	<1
Inflow from bedrock	39,800	44

Groundwater information was obtained from a GIS layer titled *Principal Aquifers of the 48 Conterminous United States* prepared by the USGS. This data set contains the shallowest principal aquifers of the conterminous United States, portrayed as polygons. The data set was developed using information from the *Ground Water Atlas of the United States.*

The mountainous areas contain bedrock aquifers that surround and are hydraulically connected to the aquifers in the Helena Valley. The Helena Valley contains part of the Northern Rocky Mountains Intermontane Basins Aquifer System, which is composed of unconsolidated sand and gravel aquifers. The aquifer in the western part of the valley is composed mostly of Quaternary alluvium, although the upper few hundred feet are composed of Tertiary sediments. The eastern part of the valley is underlain by fine-grained, poorly consolidated Tertiary sediments, which form the only available aquifer in that area (Briar and Madison, 1992).

In general, unconsolidated sand and gravel aquifers have intergranular porosity, and contain water primarily under unconfined or water table conditions. The hydraulic conductivity of the aquifers is usually high. Groundwater in these aquifers flows along relatively short flow paths typical of local flow systems. Basin-fill or valley-fill aquifers were deposited in depressions formed by faulting or erosion or both. Fine-grained deposits of silt and clay form local confining units in these aquifers, and thick sequences of the unconsolidated deposits become more compact and less permeable with depth.

The water wells map provided in Figure A-22 gives a good indication of growth and groundwater development in the Lake Helena watershed over the last century. The data set used to make the map contains point locations and selected attributes for water wells within Montana abstracted from databases maintained at the Ground-Water Information Center (GWIC) at the Montana Bureau of Mines and Geology. Original data sources include water rights filings, water well logs, visits to water wells, and publications of the Montana Bureau of Mines and Geology, the U.S. Geological Survey, and others. The databases are maintained at the Ground-Water Information Center. Data from GWIC are useful for describing the groundwater resources of Montana, land use planning, determining well drilling depths, and understanding groundwater flow. These data are currently intended to provide information on the distribution of wells in general rather than the locations of specific wells. The map shows all public supply wells and other wells in the Lake Helena watershed.

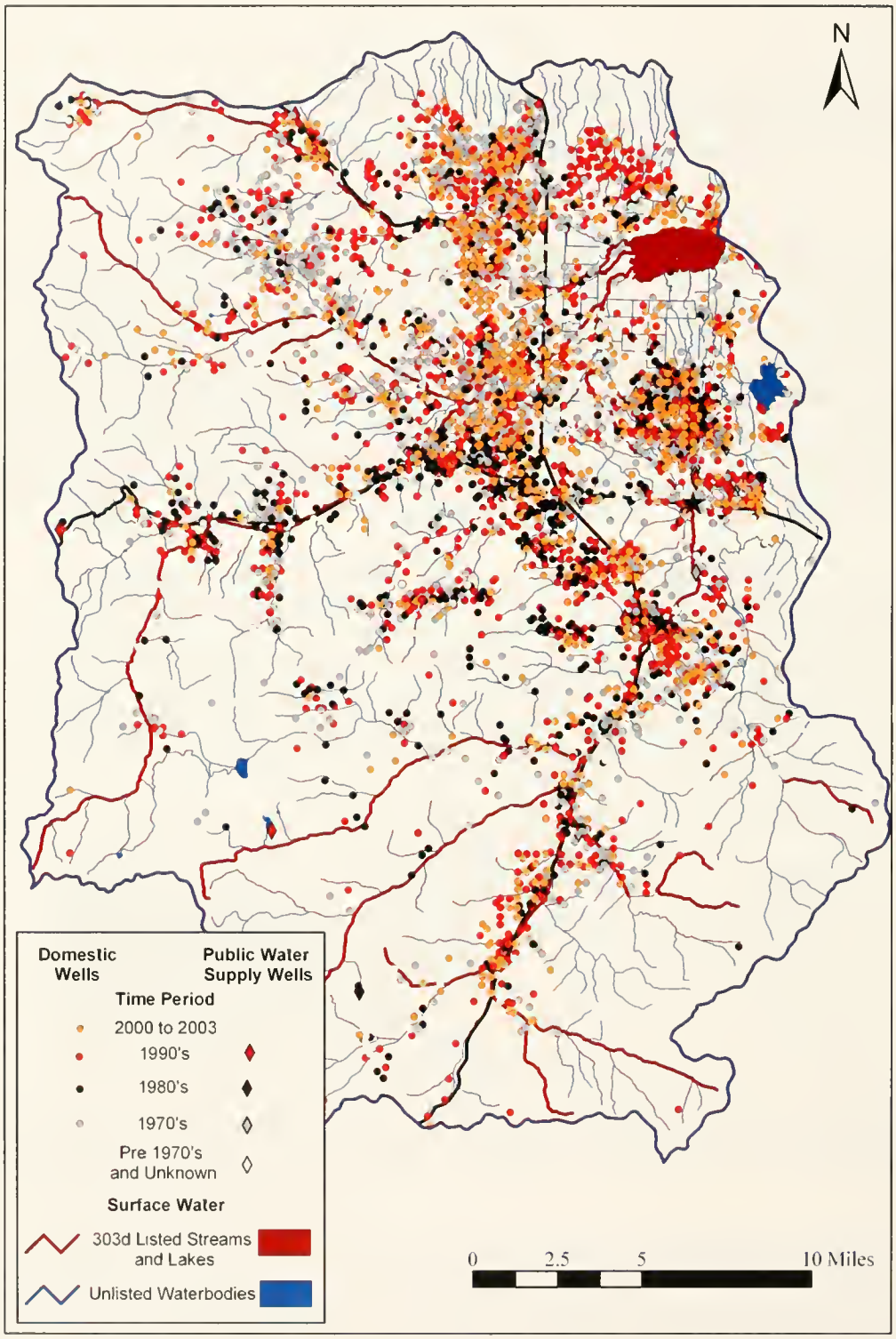


Figure A-22. State inventoried wells in the Lake Helena watershed by time period of completion.

A.1.12 Irrigation

Irrigation in the Helena Valley began in the 1880s. Water from Prickly Pear, Tenmile, and Silver creeks was diverted for irrigation purposes concurrent with the granting of land claims. Water shortages were noted as early as 1866 (Kendy et al., 1998). Canyon Ferry Dam was completed in 1953 to improve irrigation facilities (USBR, 2004a). The construction of the present irrigation system began in 1957 and was completed in 1959. By 1950, more than 8,000 acres of formerly productive land in the low-lying areas of the Helena Valley became saturated due to seepage from irrigation canals and infiltration from flood irrigated fields. The Bureau of Reclamation installed several irrigation drains beginning in 1958, in part to drain previously saturated land but also to accommodate the additional irrigation water imported from the Missouri River. Portions of some canals in the valley are lined with PVC, compacted earth, asphalt, or concrete (Kendy et al., 1998).

The Helena Valley Irrigation District receives about 81,300 acre-feet of water diverted from the Missouri River annually. The water is diverted from Canyon Ferry Dam located about 15 miles east of Helena. Turbine driven pumps below the dam (the Helena Valley Pumping Plant) lift water to the Helena Valley Canal Tunnel and feeder canal. The feeder canal flows 8.3 miles across the Spokane Bench to the 5,900 acre-ft Helena Valley Regulating Reservoir. The reservoir discharges water into the valley section of the Helena Valley Canal, which nearly encircles the Helena Valley alluvial plain and distributes water into the central part of the Helena Valley through an extensive network of lateral canals (Figure A-21). The length of the Helena Valley Canal is 31.7 miles, of which 10.2 miles are lined and 21.5 miles are unlined. Of the 64.4 miles of lateral canals, 51.9 are lined and 12.5 are unlined. A 56.6 mile drainage system consisting of 26.6 miles of open drains and 29.9 miles of pipe drains prevents irrigated land from becoming saturated (Kendy et al., 1998). This manmade drainage system has resulted in the draining of numerous acres of historic wetlands and loss of natural infiltration and groundwater recharge areas (Wetlands Community Partnership, 2001).

Irrigation practices in the Lake Helena watershed help to sustain crops through the arid summer growing season. The Helena Valley Irrigation District manages irrigation in the Helena Valley totaling 15,608 acres, of which 12,500 acres are flood irrigated. The District is proposing to increase the total irrigated acreage by 2,600 acres (Foster, 2004; USBR, 2004).

Prickly Pear Creek is severely dewatered from below East Helena nearly to Lake Helena during the irrigation season. Diversions for municipal water supply in the upper Tenmile Creek watershed, and for irrigation in lower Tenmile Creek, deplete streamflow in lower Tenmile Creek during the summer months. Some reaches go entirely dry in most years (USGS, 2001). Water from lower Tenmile Creek was first diverted for irrigation when land grants were claimed in the late 1800s (USGS, 2001). Due to irrigation diversions and other withdrawals, as well as channel and hydrologic alterations, Silver Creek is intermittent in it lower reaches.

Estimates of water leakage from the entire Helena Valley irrigation system are estimated to be about 7,060 acre-feet from mid-April through early October. The total volume of irrigation water applied to fields from all sources in 1990 was estimated to be about 57,000 acre-ft. In comparison, precipitation on irrigated areas during the 1990 irrigation season was estimated to be about 8,920 acre-ft (Briar and Madison, 1992). The previously described tile drain system in the Helena Valley is part of an extensive network of open and buried drains designed to decrease waterlogging of fields in the downgradient areas of the valley by collecting shallow groundwater and channeling it into Lake Helena. The average aquifer drainage system discharge to streams and drains is estimated to be about 50 cubic feet per second or 36,000 acre-ft/yr. Discharge from the aquifer occurs through direct upwards leakage into Lake Helena, through the bed of the lake. Because of the abundance of surface water in the Helena Valley, relatively few wells are used for large-scale irrigation. Conversely, a significant volume of water is returned to the

Helena Valley aquifer system through infiltration of excess water applied to irrigated fields (Briar and Madison, 1992).

In summary, the recharge to the Helena valley fill aquifer system is through infiltration of streamflow (12,900 acre ft/yr), leakage from irrigation canals (7,060 acre ft/yr), infiltration of excess water applied to irrigated fields (27,000 acre ft/yr), and inflow from fractures in the surrounding bedrock (39,800 acre-ft/yr). Evaporation and transpiration from non-irrigated parts of the valley exceed precipitation. Therefore, recharge from precipitation occurs only in response to infrequent periods of sustained precipitation or as part of excess water applied to irrigated fields. Discharge from the aquifer system is through leakage to streams and drains (36,200 acre/ft-year), upward leakage to Lake Helena (50,000 acre/ft-year), and withdrawals by wells (2,220 acre-ft year) (Briar and Madison, 1992).

There is a recent proposal from the City of Helena to rely on more water stored in Canyon Ferry Reservoir for its municipal supply, and less on the City's Tenmile Creek municipal supply and system of storage reservoirs. The Helena Valley Irrigation District is also involved in these discussions. The District delivers water to the City's Missouri River Treatment Plant via the Canyon Ferry Dam/Helena Valley Regulating Reservoir distribution system described earlier. At the present time, only about three percent of the water pumped out of the river is bound for the City's treatment plant.

A.1.13 Ecoregions

Omernik (1995) has defined ecoregions as areas with common ecological settings that have relatively homogeneous features including potential natural vegetation, geology, mineral availability from soils, physiography, and land use and land cover. MDEQ uses ecoregions to establish a variety of water quality targets, such as for macroinvertebrate populations and nutrient concentrations. The Lake Helena watershed contains parts of two ecoregions (see Table A-6 and Figure A-23).

Table A-6. Ecoregions in the Lake Helena Watershed.

Ecoregion	Area (acres)	Area (square miles)	Percentage
Northern Rockies	244,683	382.3	61.75
Montana Valley and Foothill Prairies	151,553	236.8	38.25
Total	352,814	619.1	100.00

Figure A-23. Ecoregions in the Lake Helena Watershed.

A.1.14 Land Use and Land Cover

General land use and land cover data for the Lake Helena watershed was extracted from the Multi-Resolution Land Characterization (MRLC) database for the State of Montana (MRLC, 1992) and is shown in Figure A-24. This database was derived from satellite imagery taken during the early 1990s and is the most current detailed land use data known to be available. Each 30-meter by 30-meter pixel contained within the satellite image is classified according to its reflective characteristics and is placed within one of several land use/land cover designations. A complete description of the MRLC land use/land cover categories is given in Appendix J. Table A-7 summarizes land characterization information for the Lake Helena watershed. Evergreen forest is the dominant land cover type, comprising approximately 41.0 percent of the total land area. Grasslands/herbaceous vegetation and shrubland make up 34.3 percent and 9.5 percent of the land area, respectively. Other important land use/land cover categories include small grains (5.5 %), pasture/hay (3.4 %), commercial/industrial/transportation (1.8 %), and fallow (1.0 %). All other categories combined make up less than one percent of the total Lake Helena watershed area.

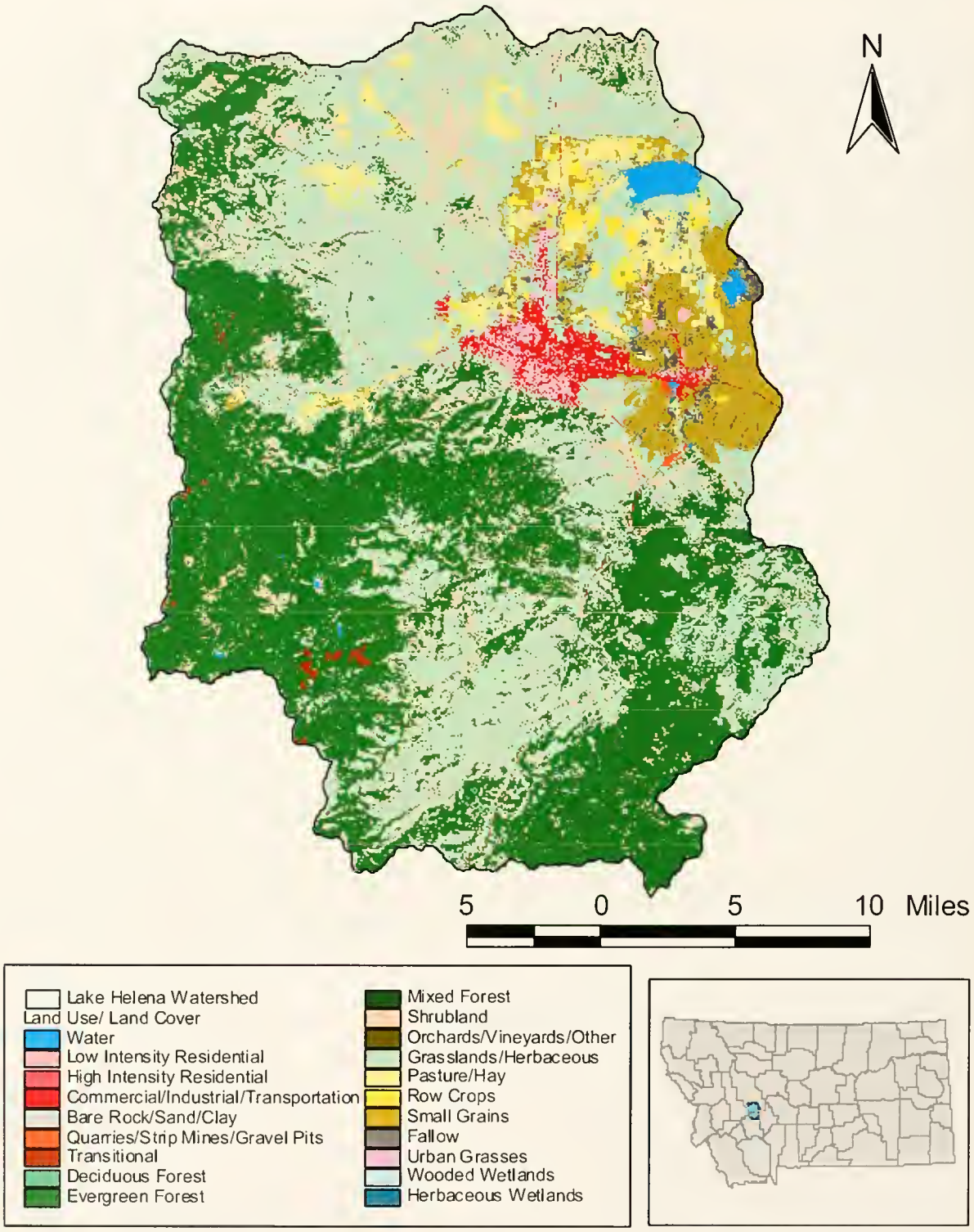


Figure A-24. Land use and land cover in the Lake Helena watershed.

Table A-7. Land use and land cover in the Lake Helena watershed.

Type of Land Use/ Land Cover	Area		Percent
	Acres	Square Miles	
Evergreen Forest	162,319	253.6	41.0
Grasslands/Herbaceous	135,833	212.2	34.3
Shrubland	37,485	58.6	9.5
Small Grains	21,781	34.0	5.5
Pasture/Hay	13,518	21.1	3.4
Commercial/Industrial/Transportation	7,071	11.0	1.8
Fallow	3,793	5.9	1.0
Row Crops	3,485	5.4	0.9
Low Intensity Residential	3,012	4.7	0.8
Water	2,844	4.4	0.7
Urban/Recreational Grasses	1,519	2.4	0.4
Deciduous Forest	1,417	2.2	0.4
Transitional	745	1.2	0.2
Woody Wetlands	687	1.1	0.2
Quarries/Strip Mines/Gravel Pits	300	0.5	< 0.1
Emergent Herbaceous Wetlands	122	0.2	< 0.1
Bare Rock/Sand/Clay	82	0.1	< 0.1
Mixed Forest	32	0.1	< 0.1
High Intensity Residential	16	< 0.1	< 0.1
Perennial Ice/Snow	6	< 0.1	< 0.1
Total	396,068	618.9	100.0

A.1.15 Vegetative Cover

Vegetative cover data were gathered from the Gap Analysis Project (GAP) completed for the State of Montana. The Gap Analysis is a nationwide program conducted under the guidance of the USGS for the purpose of assessing the extent of conservation of native plant and animal species. Since an important part of the analyses is the identification of habitat, detailed vegetative spatial data are usually available for states that have completed their analyses. Like the MRLC data, the spatial database for Montana was derived from satellite imagery taken during the early 1990s. However, the vegetative classification is much more detailed than that of the MRLC. The GAP data include vegetative species, rather than general land cover classes. The vegetative cover information for the Lake Helena watershed provided by the GAP data is shown in Figure A-25 and is summarized in Table A-8.

Table A-8 shows that the dominant vegetation cover types in the Lake Helena watershed include low/moderate cover grasslands, comprising 30.3 percent of the watershed area, and Douglas-fir which comprises 17.5 percent of the area. The grasslands are found mostly along the foothills of the mountains and in the Helena Valley. Douglas-fir vegetation areas are found primarily in the mountainous regions of the watershed. Ponderosa pine, mixed xeric forest, and lodgepole pine comprise 8.5 percent, 8.4 percent, and 6.8 percent of the area, respectively. Agricultural lands are concentrated in the valley in the northeastern portion of the watershed. Dryland crops represent 3.4 percent of the watershed, and irrigated crops account for 2.5 percent.

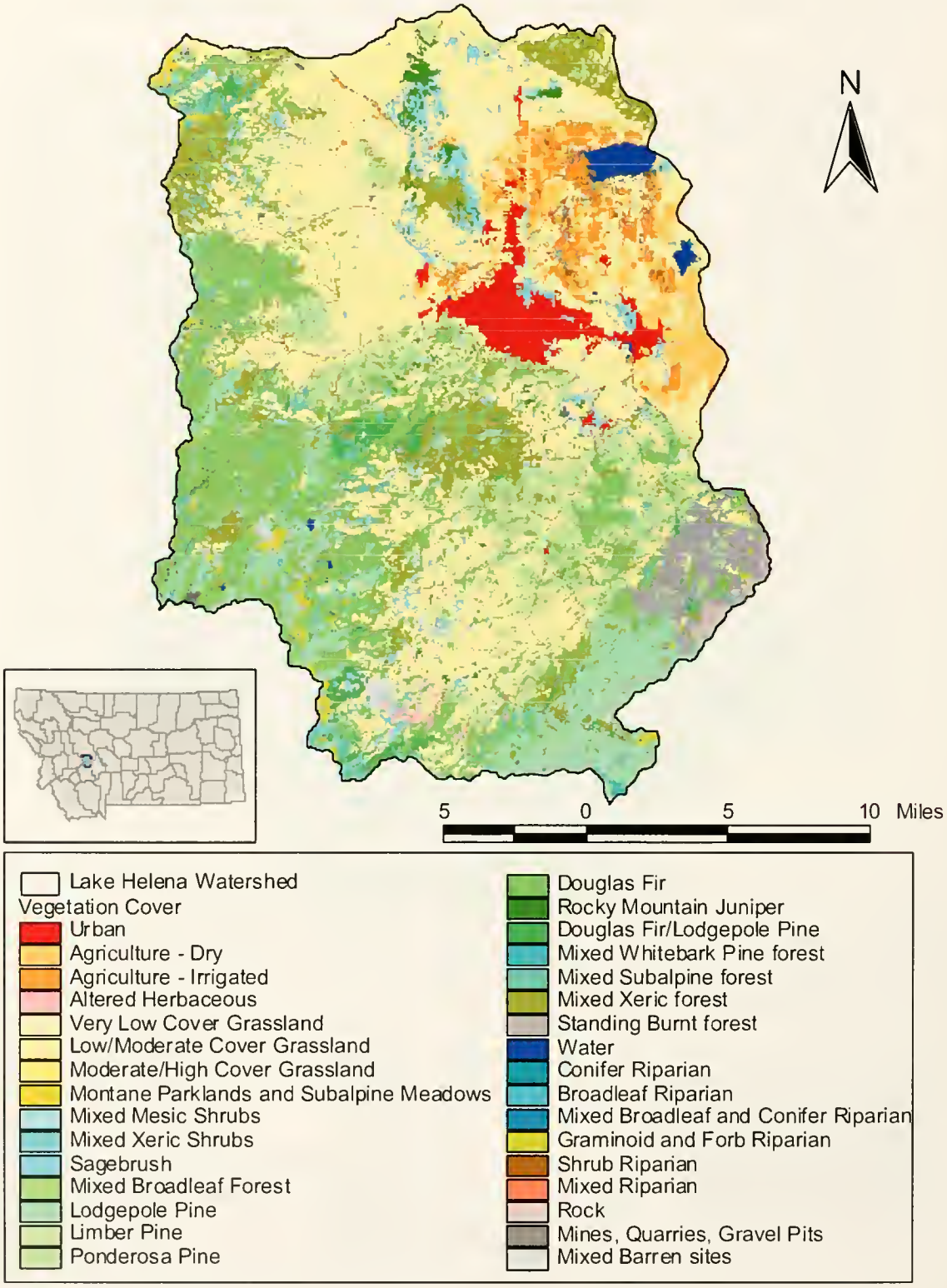


Figure A-25. Vegetative cover for the Lake Helena watershed.

Table A-8. Vegetative cover according to GAP analysis for the Lake Helena watershed.

	Area of Watershed		
Vegetative Cover Type	Acres	Square Miles	Percent
Low/Moderate Cover Grasslands	120,161	187.8	30.32
Douglas-fir	69,141	108.0	17.45
Ponderosa Pine	33,828	52.9	8.54
Mixed Xeric Forest	33,132	51.8	8.36
Lodgepole Pine	26,883	42.0	6.78
Sagebrush	14,319	22.4	3.61
Agricultural Lands – Dry	13,376	20.9	3.38
Urban or Developed Lands	12,035	18.8	3.04
Very Low Cover Grasslands	10,512	16.4	2.65
Agricultural Lands – Irrigated	9,711	15.2	2.45
Standing Burnt Forest	9,271	14.5	2.34
Mixed Subalpine Forest	7,390	11.5	1.86
Douglas-fir/Lodgepole Pine	6,681	10.4	1.69
Rocky Mountain Juniper	4,251	6.6	1.07
Montane Parklands and Subalpine Meadows	3,247	5.1	0.82
Mixed Riparian	3,080	4.8	0.78
Water	2,990	4.7	0.75
Shrub Riparian	2,656	4.2	0.67
Mixed Mesic Shrubs	2,122	3.3	0.54
Rock	1,996	3.1	0.50
Conifer Riparian	1,799	2.8	0.45
Mixed Broadleaf Forest	1,729	2.7	0.44
Mixed Broadleaf and Conifer Riparian	1,275	2.0	0.32
Mixed Barren Sites	1,009	1.6	0.25
Moderate/High Cover Grasslands	911	1.4	0.23
Broadleaf Riparian	640	1.0	0.16
Altered Herbaceous	598	0.9	0.15
Mines, Quarries, Gravel Pits	530	0.8	0.13
Mixed Xeric Shrubs	470	0.7	0.12
Mixed Whitebark Pine Forest	436	0.7	0.11
Limber Pine	46	0.1	< 0.1
Graminoid and Forb Riparian	28	0.0	< 0.1
Total	396,256	619.2	100.00

A.1.16 Channel Morphology

Channel morphology data for the Lake Helena watershed is limited, except for streams within the Helena National Forest portion of the watershed. A review of the available channel morphology data for the 303(d) listed streams is located in the preliminary source assessment (Appendix C), and in the discussion of sediment impaired streams in the water quality impairment status review section of this report (Section 3). High gradient step-pool streams are generally found in the mountainous areas of the watershed, with pool-riffle streams in the valley bottoms. In many parts of the watershed, channel morphology has been disrupted due to placer and hydraulic mining, and the creation of transportation networks.

A.2 Socio-Economic Characteristics

The following sections of the document provide information on the population of the watershed, occupations, land ownership, and important industries that can affect water quality.

A.2.1 Population

The population of the Lake Helena watershed is not directly available but can be estimated using U.S. Census data. The 2000 U.S. Census data were downloaded for all block groups whose boundaries lie wholly or partially in the watershed (Census, 2000). Census block groups are the smallest geographic unit for which demographic information is available from the Census Bureau. In the instance where a census block is located partially in the watershed, a population weighting method was used to estimate the block's contribution to the watershed population. The resulting analysis found that approximately 55,000 people live within the Lake Helena watershed, and that approximately 70 percent of the total population live in areas classified as "urban" and 30 percent live in areas classified as "non-urban".

Figure A-26 displays population densities within the watershed. Outside of municipal areas, the majority of census blocks have less than one person per square mile. However; along the I-15 corridor and in the Helena Valley, census block population densities range from 100 to well over 5,000 persons per square mile.

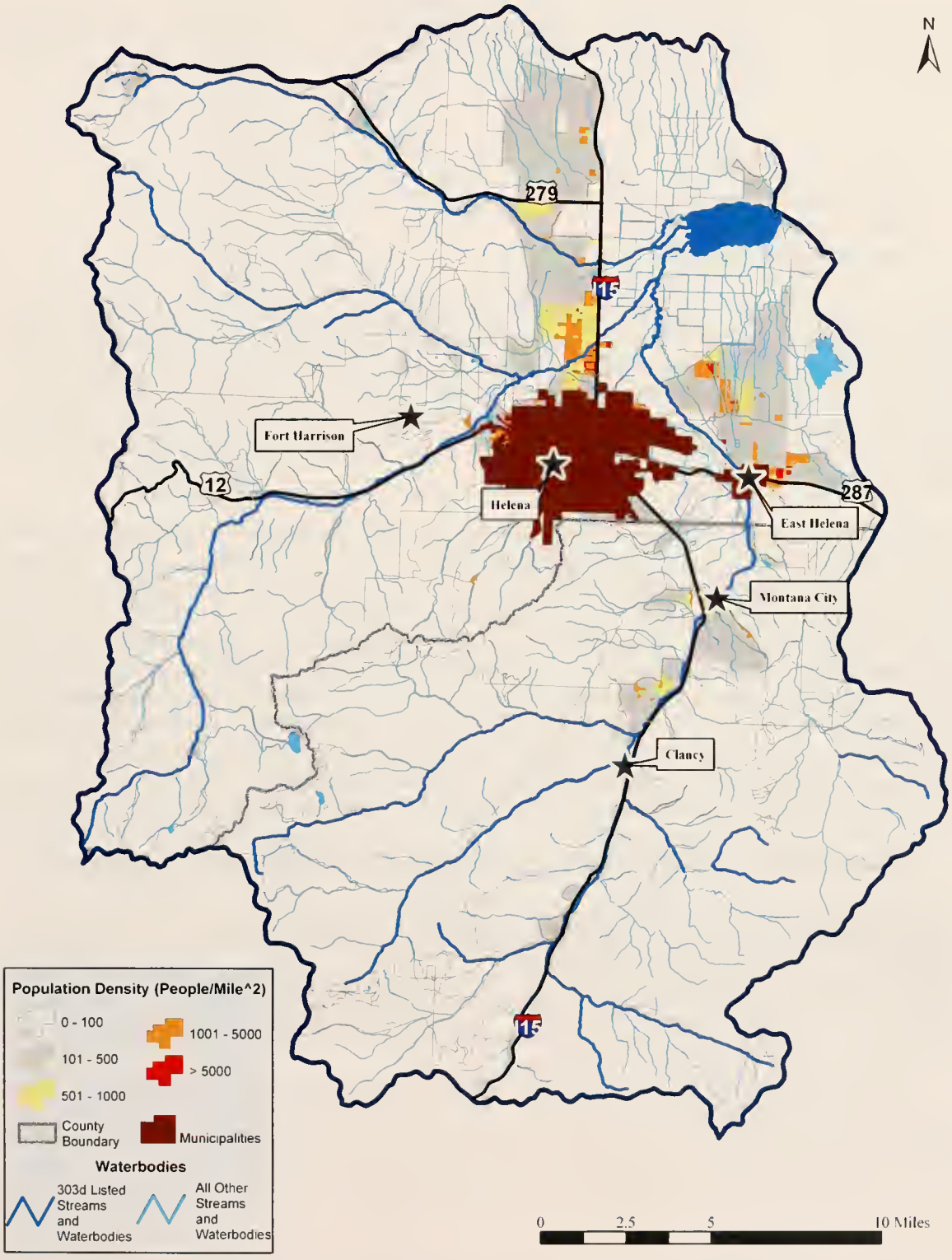


Figure A-26. Population density in the Lake Helena watershed based on the 2000 Census Blocks.

According to the most recent U.S. Census (2000), Lewis and Clark County's population was 55,716 persons in 2000, which is more than double the 1950 population of 24,540 people. The rate of population growth in the County, like the Helena Valley, has fluctuated significantly over the years, varying with the economy and other factors as shown below:

- 1950s: 14 percent increase
- 1960s: 19 percent increase
- 1970s: 29 percent increase
- 1980s: 10 percent increase
- 1990s: 17 percent increase

The projected 2010 population for Lewis and Clark County is 63,316, a nearly 14 percent increase over the 2000 population. From 1970 to 2000, the population growth rate in unincorporated portions of Lewis and Clark County (outside of Helena and East Helena) was the highest of any unincorporated area in Montana at 218 percent (Lewis and Clark County, 2004). Jefferson County is also one of the fastest growing rural counties in Montana, and is the 19th most populous with 10,049 residents according to the 2000 Census. From 1970 to 2000, Jefferson County grew by 4,796 people, a 91 percent increase in population (Jefferson County Planning Board, 2003).

Figure A-26 displays the locations of the larger cities and towns in the Lake Helena watershed, as well as the census designated urban and non-urban areas. Table A-9 summarizes area population by urban and non-urban classification and by population density within each of those classes. This table shows that the urban areas are much more densely populated than the non-urban areas. Urban areas have an average of approximately 1,661 people per square mile and non-urban areas have an average of 28 people per square mile. Table A-10 summarizes the populations of thirteen cities and towns within the Lake Helena watershed. Helena is the most populated city in the watershed, with nearly 16 times the population of East Helena, the second most populated town. Approximately 90 percent of the total urban population (44 percent of the total watershed population) resides in Helena. The population distribution is not uniform, with the majority of the population residing in urban areas surrounding Helena and East Helena. Helena is classified as an incorporated city and East Helena is classified as an incorporated town.

Table A-9. Urban population and population density in the Lake Helena watershed.

	Area		Estimated Population		Density	
Classification	Acres	Sq. Miles		Percent	Per Acre	Per Sq. Mile
Urban	14,812.14	23.14	38,451	70	2.60	1,661.38
Non-urban	381,424.05	595.98	16,694	30	0.04	28.01
Total	396,236.19	619.12	55,145	100	0.14	89.07

Table A-10. Urban population centers in the Lake Helena watershed.

City/Town	Population	County
Helena	24,346	Lewis and Clark
East Helena	1,538	Lewis and Clark
Clancy	548	Jefferson
Unionville	160	Lewis And Clark
Fort Harrison	124	Lewis and Clark
Montana City	104	Jefferson
Alhambra	100	Jefferson
Jefferson City	40	Jefferson
Marysville	40	Lewis And Clark
Corbin	20	Jefferson
Rimini	20	Lewis And Clark
Austin	5	Lewis And Clark
Wickes	5	Jefferson
Total	27,050	

The Helena Valley is the primary population center and economic hub for Lewis and Clark County, and northern Jefferson and Broadwater Counties. The Valley continues to encompass the largest percentage of Lewis and Clark County's population and growth. The majority of the growth is occurring in unincorporated areas within the Valley (Lewis and Clark County, 2004).

The number of parcels in Lewis and Clark County created through subdivision review has increased substantially since the 1980s. In 1986, for example, 94 lots were granted through subdivision review (via either preliminary or final plat approval) in the County. By 2002, that number increased to 685. Additionally, unreviewed land divisions have added to this total (Lewis and Clark County, 2004).

The housing stock in Lewis and Clark County has increased considerably during the past 30 years, more than doubling between 1970 and 2000. During this period, the most rapid growth in housing occurred during the 1970s, when 6,212 housing units were built in the County, an increase of 50 percent. As the economy slowed during the 1980s, the growth in new housing decreased considerably before rising again during the 1990s (Lewis and Clark County, 2004).

There are a number of reasons for the dramatic increase in the number of Helena Valley residences. Undeveloped land in the Valley has generally been less expensive than vacant land in Helena. Many people wanted a country-type atmosphere in which to live. Some were avoiding what were perceived as higher building costs in Helena. Some felt there were fewer development restrictions and regulations in the unincorporated area of the County. Higher property taxes in Helena may also have been a consideration.

The movement of growth from Helena to the Helena Valley has increased the burden on Lewis and Clark County for providing public services. In the more densely populated areas of the Valley, the demand for public facilities and services has increased beyond what is typically found in rural areas (Lewis and Clark

County, 2004). The population in Lewis and Clark County is expected to continue to grow, with a projected 2010 population of 63,316 and a projected 2020 population of 70,430.

These projections are based on an annual growth rate of 1.67 percent, which is slower than the annual growth rate experienced in the early 1990s (2.2 percent) but greater than the annual growth rate in the later part of the 1980s (1 percent). According to another forecast made by the City of Helena, the population of the greater Helena Valley will increase to approximately 70,000 by 2020. This constitutes an increase of 23,000 people in twenty years, nearly the equivalent of adding the population of another City of Helena to the Valley (Lewis and Clark County, 2004).

Jefferson County is also one of the fastest growing rural counties in Montana and is the 19th most populous with 10,049 residents, according to the 2000 Census. Until recently, a third of the population lived within one or two miles of the county's two towns — Whitehall and Boulder. Today, more than half of the county's residents live in the unincorporated northern part of the county and commute to Helena for work. In the 1990s, the county grew by 27 percent, adding approximately 2,000 new residents. The final Jefferson County Growth Policy was unanimously adopted by the county commission in June 2003 (Sonoran Institute, 2003). The population density is approximately 6 residents per square mile in Jefferson County. From 1970 to 2000, Jefferson County grew by 4,796 people, a 91 percent increase in population (Jefferson County, 2003). In the last 10 years, the towns of Montana City and Clancy have sprouted so rapidly that they have catapulted Jefferson County into the fourth fastest-growing county in the State. From 1990 to 2000, the county gained 26.6 percent more residents (Great Falls Tribune, 2003).

A.2.2 Occupation

Table A-11 and Table A-12 show the occupation and industry of residents in Jefferson County and Lewis and Clark County, respectively. Estimates are based on a one-in-six sample of housing units that received the long form as part of the 2000 Census. The Lake Helena watershed is comprised of portions of each county, so the data are not specific to the population within the watershed but rather include people who live in surrounding areas as well as within the watershed.

Table A-11 and Table A-12 show that the majority of people in both counties (approximately 39 %) hold management, professional, and related occupations. Sales and office occupations and service occupations are also significant. The least amount of people in both counties (approximately one percent) participates in farming, fishing, and forestry occupations. Other occupation fields include construction, extraction, and maintenance occupations, and production, transportation, and material moving occupations.

The top three industries in both Jefferson County and Lewis and Clark County, in terms of people employed, are education, health and social services, public administration, and retail trade (Table A-11 and Table A-12). In Jefferson County, other major industries are construction (8.4 %), agriculture, forestry, fishing and hunting, and mining (8.4 %), and arts, entertainment, recreation, accommodation and food services (7.9 %). In Lewis and Clark County, other important industries include arts, entertainment, recreation, accommodation and food services (8.9 %), professional, scientific, management, administrative, and waste management services (8.4 %), and finance, insurance, real estate, and rental leasing (7.6 %).

Table A-11. Occupation and employment industry of residents in Jefferson County.

OCCUPATION	People	Percent
Management, professional, and related occupations	1,925	39.3
Sales and office occupations	1,129	23.1
Service occupations	797	16.3
Construction, extraction, and maintenance occupations	583	11.9
Production, transportation, and material moving occupations	384	7.8
Farming, fishing, and forestry occupations	77	1.6
INDUSTRY	**People**	**Percent**
Educational, health and social services	1,015	20.7
Public administration	754	15.4
Retail trade	424	8.7
Construction	411	8.4
Agriculture, forestry, fishing and hunting, and mining	410	8.4
Arts, entertainment, recreation, accommodation and food services	388	7.9
Professional, scientific, management, administrative, and waste management services	321	6.6
Finance, insurance, real estate, and rental and leasing	320	6.5
Transportation and warehousing, and utilities	236	4.8
Other services (except public administration)	218	4.5
Manufacturing	186	3.8
Wholesale trade	120	2.5
Information	92	1.9
Total number of people (employed civilian population 16 years and older)	4,895	100.0

Table A-12. Occupation and employment industry of residents in Lewis and Clark County.

OCCUPATION	People	Percent
Management, professional, and related occupations	11,350	39.6
Sales and office occupations	7,886	27.5
Service occupations	4,217	14.7
Production, transportation, and material moving occupations	2,548	8.9
Construction, extraction, and maintenance occupations	2,358	8.2
Farming, fishing, and forestry occupations	292	1.0
INDUSTRY	**People**	**Percent**
Educational, health and social services	5,418	18.9
Public administration	4,934	17.2
Retail trade	3,086	10.8
Arts, entertainment, recreation, accommodation and food services	2,540	8.9
Professional, scientific, management, administrative, and waste management services	2,405	8.4
Finance, insurance, real estate, and rental and leasing	2,185	7.6
Construction	1,870	6.5
Other services (except public administration)	1,559	5.4
Manufacturing	1,073	3.7
Information	1,052	3.7
Transportation and warehousing, and utilities	1,011	3.5
Agriculture, forestry, fishing and hunting, and mining	857	3.0
Wholesale trade	661	2.3
Total number of people (employed civilian population 16 years and over)	28,651	100.0

A.2.3 Land Ownership

Various private, tribal, state and federal agencies hold title to portions of the watershed, as shown in Figure A-27. Land ownership is summarized for the watershed as a whole in Table A-13. The majority of the land is privately owned, totaling 231,974 acres or 58.5 percent of the watershed area. Federal land holdings, represented by agencies such as the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM), comprise a total of 159,911 acres or roughly 40 percent of the watershed area. The Forest Service is the largest federal landowner in the watershed, and represents the second largest land ownership in the watershed overall with responsibility for 118,718 acres, or about 30 percent of the total watershed area. Land holdings by the BLM, the Montana Department of Natural Resources and Conservation (DNRC), and the Department of Defense represent 8.1 percent, 1.4 percent, and 0.8 percent of total watershed area, respectively.

Table A-13. Land ownership in the Lake Helena watershed.

	Area		
Land Ownership Description	**Acres**	**Square Miles**	**Percent**
Private land	231,974	362.5	58.5
US Forest Service	118,718	185.5	30.0
Bureau of Land Management	32,264	50.4	8.1
Department of Natural Resources & Conservation	5,696	8.9	1.4
Other Department of Defense	3,233	5.1	0.8
Water	2,832	4.4	0.7
City parks or open space	775	1.2	0.2
Bureau of Reclamation	467	0.7	0.1
Montana Fish, Wildlife & Parks	264	0.4	0.1
Prickly Pear Land Trust	13	0.0	< 0.1
Total	396,236	619.1	100.0

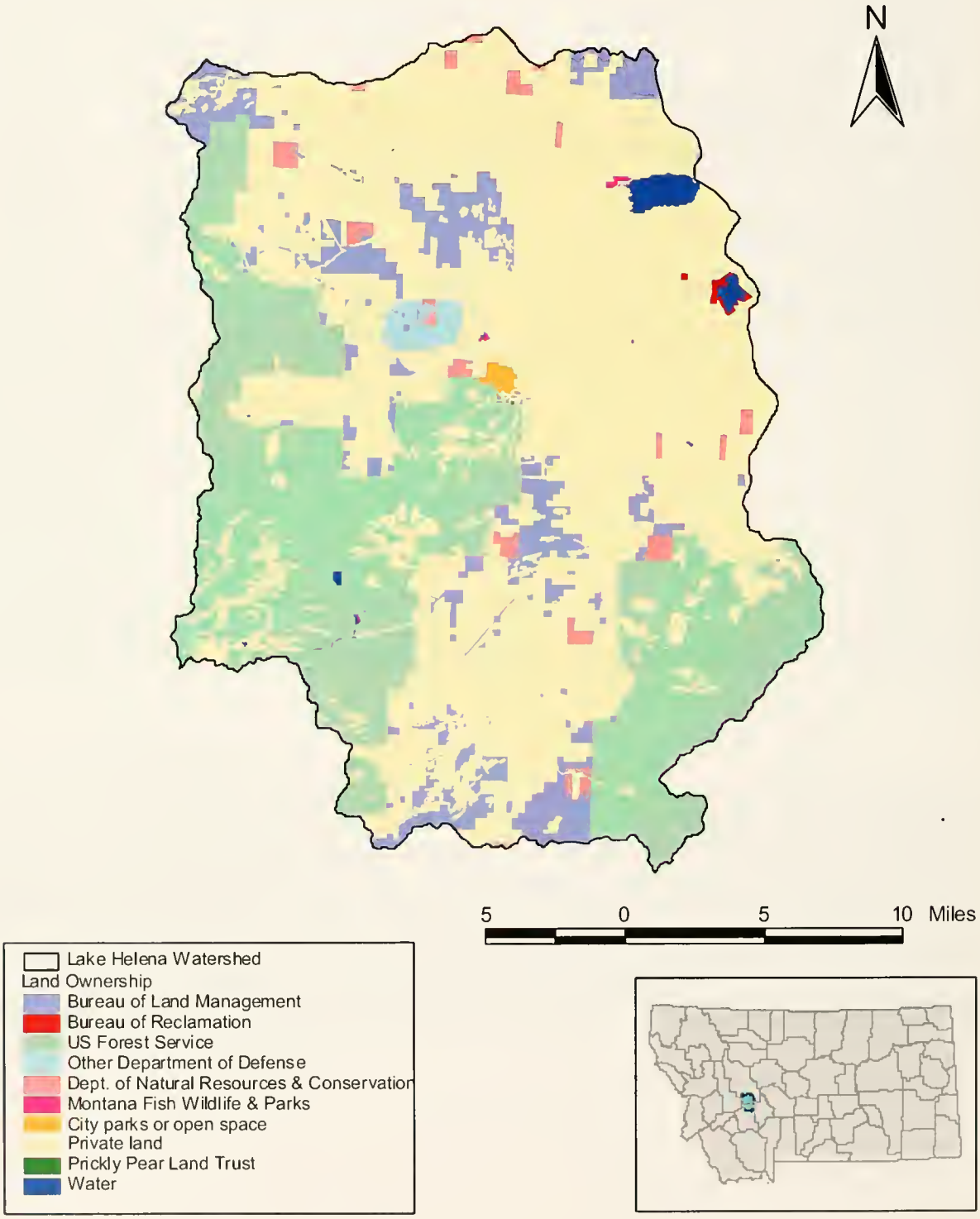


Figure A-27. Land ownership in the Lake Helena watershed.

A.2.4 Industry

Several industries within the Lake Helena watershed are important for their potential impact to water quality. These include mining, agriculture, and forestry.

A.2.5 Mining

Helena began as a small mining town following the discovery of gold in 1864, and mining remains an active industry in the Lake Helena watershed area. Gold, silver, and copper are the primary minerals that are mined in the Lake Helena watershed and surrounding areas. Other common minerals mined within the watershed and vicinity include lead, zinc, manganese, and uranium. The mining districts within the Lake Helena watershed include the following: Missouri River, Marysville, Scratch Gravel Hills, Austin, Blue Cloud, Helena, Rimini, Montana City, McClellan, Clancy, Alhambra, Colorado, and Elkhorn. These districts were delineated by the Montana Abandoned Mines Reclamation Bureau in 1935 and were revised in 1995.

Metal and Limestone Mines

Table A-14 lists the names, types, sizes and locations of metal and limestone mines in the Lake Helena watershed. This information was obtained from Montana DEQ's Environmental Management Bureau. There are a total of 37 metal and limestone mines within the Lake Helena watershed, however not all these mines are currently active.

Table A-14. Metal and limestone mines in the Lake Helena watershed.

Name	Mineral	Acres	County	Location
Private Owner	Gold, Silver	**	Lewis and Clark	Sec. 32 and 33, T9N, R5W
DEQ, Mine Waste Cleanup	Gold	1.0	Lewis and Clark	Sec. 1 and 2, T9N, R4W
EcoSafe Gold Recovery LLC	Gold	2.2	Lewis and Clark	Sec. 10, T9N, R4W
Private Owner	Gold	**	Lewis and Clark	Sec. 21 and 22, T11N, R2W
Private Owner	Gold, Copper, Silver	.5	Lewis and Clark	Sec. 34 and 33, T12N, R6W
Private Owner	Gold	.5	Lewis and Clark	Sec. 27 and 28, T11N, R4W
Private Owner	Lead, Silver	**	Lewis and Clark	Sec. 6, T8N, R5W
Private Owner	Gold	.25	Lewis and Clark	Sec. 11 and 13, T11N, R6W
Private Owner	Gold, Lead, Silver, Zinc	2.0	Lewis and Clark	Sec. 20, 21, 28 and 29, T8N, R5W
Private Owner	Gold	.10	Lewis and Clark	Sec. 17, T10N, R5W
Private Owner	Gold	2.0	Lewis and Clark	Sec. 2 and 3, T9N, R4W
Private Owner	Gold	.10	Lewis and Clark	Sec. 11, T9N, R4W
Private Owner	Gold, Silver	2.0	Lewis and Clark	Sec. 20, T8N, R5W

Name	Mineral	Acres	County	Location
Private Owner	Gold	.50	Lewis and Clark	Sec. 6 and 7, T10N, R4W Sec. 36, T11N, R5W
Private Owner	Gold, Silver	**	Lewis and Clark	Sec. 16, 20, 22 and 23, T9N, R4W
Private Owner	Gold	.25	Lewis and Clark	Sec. 1, T10N, R4W
Private Owner	Copper, Gold, Silver	1.50	Lewis and Clark	Sec. 36, T11&12N, R6W
Private Owner	**	.10	Lewis and Clark	Sec. 2 and 11, T9N, R4W
Private Owner	Gold	1.0	Lewis and Clark	Sec. 22 and 23, T11N, R4W
Private Owner	Gold	2.0	Lewis and Clark	Sec. 23, T11N, R4W
Private Owner	Gold	*	Lewis and Clark	Sec. 23N, T11N, R4W
Westmark International Corp.	Gold	1.0	Lewis and Clark	Sec. 1, T11N, R5W
Whitehawk Mineral Co.	Limestone	4.0	Lewis and Clark	Sec. 5, T10N, R5W
Private Owner	Gold	**	Lewis and Clark	Sec. 2, T8N, R5W
Ash Grove Cement Co.	Limestone	145.0	Lewis and Clark Jefferson	Sec. 7 and 8, T9N, R2W Sec. 12 and 13, T9N, R3W
Montana Tunnels Mining Inc.	Gold, Silver	6,125	Lewis and Clark Jefferson	Sec. 4, 5, 8, 9, 16, 17 and 20, T7N, R4W
Pegasus Gold Montana	Gold, Silver	1,804	Lewis and Clark Jefferson	Sec. 24, 25 and 35, T8N, R6W Sec. 19 and 20, T8N, R5W
Private Owner	Gold, Silver	1.0	Jefferson	Sec. 17, T8N, R4W
Private Owner	Gold	.25	Jefferson	Sec. 23 and 26, T9N, R3W
Private Owner	Gold	.25	Jefferson	Sec. 17, T8N, R2W
Private Owner	Gold, Silver	4.0	Jefferson	Sec. 13 and 14, T8N, R4W
Lindsay & Son Drilling	Silica	.20	Jefferson	Sec. 2, T7N, R3W
Private Owner	Gold, Copper, Lead, Silver	2.0	Jefferson	Sec. 29, T7N, R3W
Mineral Rights Unlimited	Gold	5.1	Jefferson	Sec. 1, 2 and 11, T9N, R3W
Private Owner	Gold	5.0	Jefferson	Sec. 7, 8, 17 and 18, T9N, R3W
Private Owner	Gold	Not listed	Jefferson	Sec. 18, T9N, R3W

Name	Mineral	Acres	County	Location
Xanudu Mining Co. LLC	Gold, Platinum	Not listed	Jefferson	Sec. 28, T7N, R4W

* These sites are inactive.
** These sites have been shut down.

Sand and Gravel Mines

Table A-15 lists the names, sizes and locations of sand and gravel mines in the Lake Helena watershed. This information was obtained from Montana DEQ's Environmental Management Bureau. There are a total of 20 sand and gravel mines mines located within the boundaries of the Lake Helena watershed.

Table A-15. Sand and gravel mines in the Lake Helena watershed.

Name	Acres	County	Location
Big Sky Ready Mix	100.00*	Lewis and Clark	NW¼SE¼ & N½SW¼, Sec. 7, T10N, R2W
Fisher Sand & Gravel	19.5	Lewis and Clark	SW¼NE¼, Sec. 7, T12N, R5W
Gilman, Jim Excavating	4.5	Lewis and Clark	NW¼NW¼, Sec. 36, T10N, R2W
Helena Sand & Gravel	16	Lewis and Clark	SE¼SW¼, Sec. 23, T10N, R3W
Helena Sand & Gravel	16.2	Lewis and Clark	NE¼SW¼, Sec. 23, T10N, R3W
Helena Sand & Gravel	304.00*	Lewis and Clark	W½W½E½, Sec. 17, T10N, R2W
Helena Sand & Gravel	30	Lewis and Clark	NW¼NW¼, N½SE¼, NW¼, Sec. 23, T10N, R3W
Helena Sand & Gravel	35	Lewis and Clark	SE¼NE¼, Sec. 23, T10N, R3W
Helena Sand & Gravel	80	Lewis and Clark	E½SE¼, Sec. 14, T10N, R3W
Jim Clark & Sons Contracting	10.5	Lewis and Clark	SE¼NW¼, Sec. 32, T11N, R2W
Private Owner	141.75	Lewis and Clark	W½SE¼, Sec. 13, T11N, R4W
Lewis & Clark County	2.5	Lewis and Clark	Sec. 16, T10N, R3W
Lewis & Clark County	40	Lewis and Clark	W½SW¼, Sec. 18, T11N, R3W
Lewis & Clark County	0.5	Lewis and Clark	SW¼, Sec. 16, T9N, R5W
Menth Excavating Inc	10	Lewis and Clark	SW¼SE¼, Sec. 34, T11N, R3W
Riverside Contracting	9.9	Lewis and Clark	SW¼, Sec. 35, T10N, R5W
SK Construction	18.90**	Lewis and Clark	NW¼, Sec. 22, T10N, R3W
Bluffs Company	7.50	Jefferson	SW¼SW¼, Sec. 34, T9N, R3W
Jefferson County	1.00	Jefferson	SW¼SW¼, Sec. 13, T9N, R3W
Jefferson County	1.50	Jefferson	SW¼SW¼, Sec. 15, T9N, R3W

* These sites have not been mined to date.
** This site is reclaimed and released.

Small Mines

Table A-16 and Table A-17 show the types, sizes and land ownership of small mines in Jefferson and Lewis and Clark counties. This information was obtained from Montana DEQ's Environmental Management Bureau. There are a total of 44 small mines within both counties, however not all these mines are located within the boundaries of the Lake Helena watershed. The majority of the land where the mines are located is owned by the Helena National Forest or by private owners.

Table A-16. Small mines in Jefferson County.

Operation Type	Acres	Landowner	Within watershed ?
Open Pit	0.2	Forest Service	N/A
Open Pit	N/A	N/A	N/A
Open Pit	N/A	BLM	N/A
Open Pit	2	Private	N/A
Open Pit	N/A	Private	N/A
Placer	5.1	Private	Yes
Placer	4	BLM	Yes
Placer	1	Private	Yes
Placer	0.1	Forest Service	No
Placer	0.25	BLM	Yes
Placer	0.1	Forest Service	No
Placer	0.7	Forest Service	N/A
Placer	5	Private	Yes
Underground	N/A	Private	N/A
Underground	0.25	Forest Service	No
Underground	N/A	Forest Service, Private	N/A
Underground	4	Forest Service	No
Underground	N/A	Forest Service	No
Underground	0.25	Forest Service	N/A
Underground, Open Pit	0.25	Forest Service, Private	N/A
Underground, Open Pit	3	Private	N/A
Underground, Open Pit	3	Private	N/A
Underground, Placer	0.33	Forest Service	N/A

Table A-17. Small mines in Lewis and Clark County.

Operation Type	Acres	Landowner	Within watershed?
Open Pit	N/A	Private	Yes
Open Pit	0.1	Forest Service	Yes
Open Pit	0.1	Forest Service	Yes
Open Pit	2	Forest Service	N/A
Open Pit	2	Forest Service	N/A
Open Pit	1.5	BLM, Forest Service	N/A
Open Pit	4	BLM	Yes
Open Pit, Placer	2	Private	Yes
Open Pit, Underground	0.5	Forest Service	N/A
Placer	1	Private	Yes
Placer	0.1	Private	Yes
Placer	N/A	Private	N/A
Placer	1	BLM	Yes
Placer	2	BLM	Yes
Placer	0.5	BLM	Yes
Prospecting	0.5	Forest Service, State	Yes
Underground	0.25	BLM	Yes
Underground	N/A	Forest Service	Yes
Underground	N/A	Private	N/A
Underground	N/A	Forest Service, Private	Yes
Underground	N/A	Forest Service	N/A

Abandoned Mines

The Montana Department of Environmental Quality's Abandoned Mine Reclamation Section of the Mine Waste Cleanup Bureau oversees the reclamation of abandoned mines in Montana. Abandoned mines are ranked in a priority order for reclamation based on the protection of public health, safety, welfare and property from: 1) extreme danger, 2) adverse effects of mineral mining and processing, and 3) the restoration of land and water resources. The Mine Waste Cleanup Bureau's priority list ranks all the known abandoned mines and mine affected sites in the state in need of remediation. Table A-18 shows the abandoned mines in the Lake Helena watershed which have undergone reclamation. In many of instances where no mineral is listed, a structural hazard such as an adit, has been reclaimed. In the Lake Helena watershed, 74 abandoned mine sites have undergone clean-up, while 335 remain on the list for remediation.

Table A-18. Reclaimed abandoned mines in the Lake Helena watershed.

Name	Mineral	County	Location
96 Phoenix	NA	Lewis and Clark	Sec.36, T10N, R4W
Aster	NA	Lewis and Clark	Sec.33, T11N, R4W
Bald Mountain Marysville Dist.	Gold, Silver	Lewis and Clark	Sec.35, T12N, R6W
Blue Cloud I	NA	Lewis and Clark	Sec.30, T10N, R4W
Blue Cloud II	NA	Lewis and Clark	Sec.12, T10N, R5W
Bonanza Gray Rock	Lead	Lewis and Clark	Sec.36, T11N, R4W
Broadwater	NA	Lewis and Clark	Sec.28, T10N, R4W
Chaucer Quarry	NA	Lewis and Clark	Sec.31, T10N, R3W
Colorado Gulch	Tungsten	Lewis and Clark	Sec.13, T9N, R5W
Contention	NA	Lewis and Clark	Sec.15, T9N, R4W
Crossroads	NA	Lewis and Clark	Sec.1, T11N, R6W
Cycle	NA	Lewis and Clark	Sec.35, T10N, R4W
Davis Gulch I	NA	Lewis and Clark	Sec.31, T10N, R3W
Davis Gulch III	NA	Lewis and Clark	Sec.1, T9N, R4W
Dry Gulch Helena Dist.	Calcium	Lewis and Clark	Sec.12, T9N, R4W
Elma	NA	Lewis and Clark	Sec.27, T11N, R4W
Gray Rock	Zinc, Copper, Gold	Lewis and Clark	Sec.11, T9N, R4W
Grizzly Gulch II	Calcium	Lewis and Clark	Sec.3, T9N, R4W
Grizzly Gulch III	Calcium	Lewis and Clark	Sec.36, T10N, R4W
Hawkeye Helena Dist.	NA	Lewis and Clark	Sec.31, T10N, R3W
Head Lane	NA	Lewis and Clark	Sec.34, T11N, R4W
Howard Grizzly Gulch I	NA	Lewis and Clark	Sec.35, T10N, R4W
Independence Helena Dist.	Copper, Gold, Uranium, Zinc	Lewis and Clark	Sec.11, T9N, R4W
John G Mine I	NA	Lewis and Clark	Sec.26, T11N, R4W
John G Mine II	NA	Lewis and Clark	Sec.26, T11N, R4W
Julia Scratchgravel Dist.	NA	Lewis and Clark	Sec.2, T10N, R4W
Justice Rimini Dist.	Lead, Silver, Zinc, Gold	Lewis and Clark	Sec.6, T8N, R5W
Le Grand Canyon	NA	Lewis and Clark	Sec.27, T10N, R4W
Lexington Scratchgravel Dist.	Silver	Lewis and Clark	Sec.35, T11N, R4W
Lombardy	NA	Lewis and Clark	Sec.27, T10N, R4W

Name	Mineral	County	Location
May Be So	NA	Lewis and Clark	Sec.4, T9N, R3W
McLeod	NA	Lewis and Clark	Sec.2, T10N, R4W
Mount Helena Park	NA	Lewis and Clark	Sec.36, T10N, R4W
Mt Ascension Heights	NA	Lewis and Clark	Sec.31, T10N, R3W
North Star Marysville Dist.	NA	Lewis and Clark	Sec.36, T12N, R6W
Northside	NA	Lewis and Clark	Sec.36, T12N, R6W
Oompaul	NA	Lewis and Clark	Sec.35, T11N, R4W
Orofino Ridge	NA	Lewis and Clark	Sec.1, T9N, R4W
Pearson	NA	Lewis and Clark	Sec.1, T10N, R4W
Red Letter	NA	Lewis and Clark	Sec.4, T9N, R3W
Scratchgravel I	Gold	Lewis and Clark	Sec.1, T10N, R4W
Shannon	Gold, Silver	Lewis and Clark	Sec.3, T11N, R6W
South Saddle	NA	Lewis and Clark	Sec.1, T10N, R4W
Spring Hill Tailings	Lead, Copper, Gold	Lewis and Clark	Sec.3, T9N, R4W
Susie	NA	Lewis and Clark	Sec.6, T9N, R3W
War Eagle Austin Dist.	Lead, Silver, Iron	Lewis and Clark	Sec.10, T10N, R5W
Witch Of Ender	NA	Lewis and Clark	Sec.1, T10N, R4W
Sparta	NA	Lewis and Clark	Sec. 36, T10N, R4W
Touchstone II	NA	Lewis and Clark	Sec. 31, T10N, R3W
Alta	Gold, Lead, Silver, Zinc	Jefferson	Sec.10, T07N, R4W
Diehl I	NA	Jefferson	Sec.5, T9N, R3W
Diehl II	NA	Jefferson	Sec.5, T9N, R3W
Dike	NA	Jefferson	Sec.18, T9N, R2W
Euclid	Gold, Silver	Jefferson	Sec.17, T8N, R2W
Haynes II	NA	Jefferson	Sec.17, T8N, R3W
Kaiser Augusta	NA	Jefferson	Sec.18, T9N, R2W
Lump Gulch	NA	Jefferson	Sec.32, T9N, R3W
Marks Lump Gulch	NA	Jefferson	Sec.4, T8N, R3W
Marks Ridge Line	NA	Jefferson	Sec.7, T8N, R3W
Maupin Creek	NA	Jefferson	Sec.17, T8N, R2W
McClellan Creek	NA	Jefferson	Sec.32, T9N, R2W
Meadow	Lead, Silver, Zinc	Jefferson	Sec.34, T9N, R3W
Mill Creek McClellan Dist.	NA	Jefferson	Sec.7, T8N, R2W
Moonlight Clancy Dist.	NA	Jefferson	Sec.33, T9N, R3W
Nancy Hanks Faith Hope	NA	Jefferson	Sec.9, T9N, R3W
Nellie Grant	Lead, Silver, Gold	Jefferson	Sec.14, T8N, R5W
New Stake	Silver, Zinc	Jefferson	Sec.9, T8N, R3W
Old Abe	NA	Jefferson	Sec.33, T9N, R3W
Overland	NA	Jefferson	Sec.18, T9N, R2W
Strawberry Creek	NA	Jefferson	Sec.7, T8N, R2W
Tick City	NA	Jefferson	Sec.8, T8N, R3W
Tycoon	NA	Jefferson	Sec.33, T9N, R3W
Walker I	NA	Jefferson	Sec.4, T9N, R3W
Walker II	NA	Jefferson	Sec.3, T9N, R3W

Figure A-28 shows the distribution of abandoned mines within the Lake Helena watershed. The locations of these mines were obtained from a GIS coverage published by the Montana State Library in cooperation with the Montana Bureau of Mines and Geology. The data was generated from the U.S. Bureau of Mines' Minerals Industry Location System (MILS) database in October 2002. According to this source, there are 427 abandoned mines within the Lake Helena watershed.

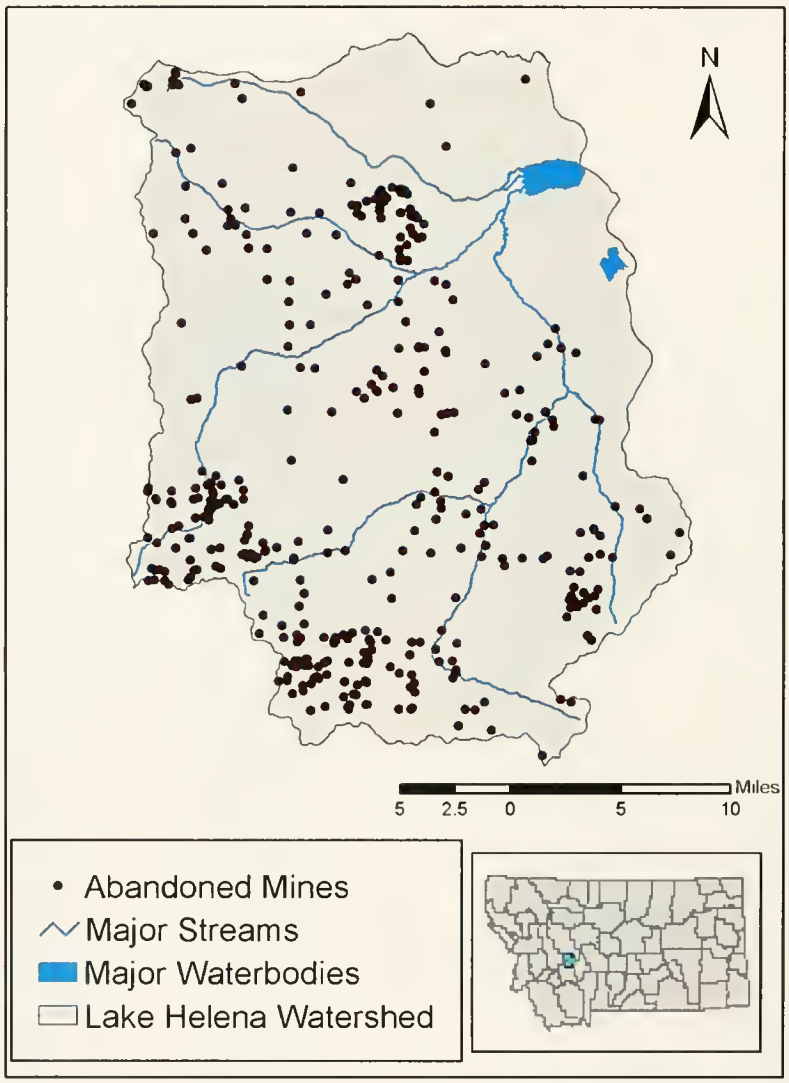


Figure A-28. Location of abandoned mines within the Lake Helena watershed.

A.2.6 Agriculture

According to the U.S. Department of Agriculture's 1997 Agricultural Census, there are a total of 768 farms in Jefferson and Lewis and Clark counties (USDA, 1997). Of those, 502 are located in Lewis and Clark County and 266 are in Jefferson County. They cover approximately 1,853 square miles of land in total. In both counties, the number of farms has increased from 1987 to 1997, but the average sizes of the farms and the total amount of farmland have decreased.

A.2.7 Forestry

Forestry is another important industry in the Lake Helena watershed. According to the U.S. Forest Service Forest Inventory and Analysis Database Retrieval System, there are approximately 833 square miles of forestland in Jefferson and Lewis and Clark counties. Table A-19 shows the estimated area of forested land in square miles by county. Although the majority of the land (70 %) in the two counties is non-forest, nearly 93 percent of the forest land is timberland.

Table A-19. Forested area in Jefferson County and Lewis and Clark County.

County	All land (sq. mi.)	Total forest (sq. mi.)	Timberland (sq. mi.)	Other forest (sq. mi.)	Reserved Timberland (sq. mi.)	Non-forest land (sq. mi.)
Jefferson	856.1	202.3	199.7	2.7	0.0	653.9
Lewis & Clark	1978.4	631.4	574.8	6.7	49.8	1347.0
Total	2834.5	833.8	774.5	9.4	49.8	2000.9

A.2.8 Point Sources

In 2003, the Montana DEQ's Water Protection Bureau provided information on the active permitted point source wastewater discharges in the Lake Helena watershed. There are approximately twenty-one active point sources in the watershed, including standard Montana Pollution Discharge Elimination System (MPDES) permitees, individual or general permits, stormwater discharge permits, and general industrial or general mining permits. Active permits are described in Table A-20.

Table A-20. Active point source discharge permits in the Lake Helena watershed.

Permit ID	Permit Holder	Type of Permit
MT0000426	AIR LIQUIDE AMERICA CORP	STANDARD
MT0030147	ASARCO INC. (EAST HELENA)	STANDARD
MTR000072	ASARCO INCORPORATED	STORMWATER
MT0000451	ASH GROVE CEMENT COMPANY	STANDARD
MTR300113	ASH GROVE CEMENT COMPANY	STORMWATER
MT0028690	BASIN CREEK MINING INC	STANDARD
MTR000418	BUILDING MATERIALS HOLDING COR	STORMWATER
MT0022560	EAST HELENA - CITY OF	STANDARD
MT0023566	EVERGREEN NURSING HOME	STANDARD
MTG790002	EXXON - HELENA TERMINAL	GENERAL
MTR000271	HELENA REGIONAL AIRPORT	STORMWATER
MT0028720	HELENA, CITY OF (WTP)	STANDARD
MT0022641	HELENA-CITY OF	STANDARD
MT0000949	HELENA-CITY OF (WTP)	STANDARD
MTR000363	LEWIS & CLARK COUNTY LANDFILL	STORMWATER
MTR000006	AIR LIQUIDE AM CORP	STORMWATER
MT0025020	MONTANA GOLD & SAPPHIRES INC	STANDARD
MTR000361	MONTANA RAIL LINK	STORMWATER
MT0028428	MONTANA TUNNELS MINING, INC	STANDARD
MTR000430	PACIFIC STEEL AND RECYCLING	STORMWATER
MTR000334	UPS HELENA CENTER	STORMWATER

Appendix B: Montana Water Quality Standards

B.0 WATER QUALITY STANDARDS

B.1 Classification and Beneficial Uses

Classification is the assignment (designation) of a single or group of uses to a water body based on the potential of the water body to support those uses. Designated uses or beneficial uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of "uses" of state waters, including: growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. The Montana Water Quality Act (WQA) directs the Board of Environmental Review (BER, i.e., the state) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (Administrative Rules of Montana (ARM) 17.30.607-616) and to adopt standards to protect those uses (ARM 17.30.620-670).

Montana, unlike many other states, uses a watershed based classification system with some specific exceptions. As a result, *all* waters of the state are classified and have designated uses and supporting standards. All classifications have multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply. However, the quality of that water body must be maintained as suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or non-point source discharges may not make the natural conditions worse.

Descriptions of Montana's surface water classifications and designated beneficial uses are presented in Table B-1. All water bodies within the Lake Helena watershed are classified as B-1, with two exceptions. Tenmile Creek from its headwaters to the Helena public water supply intake above Rimini is classified A-1, and Prickly Pear Creek from the Highway 433 crossing to Lake Helena is classified I. The geographic distribution of stream classifications within the Lake Helena watershed is shown in Figure B-1.

B.2 Standards

In addition to the Use Classifications described above, Montana's water quality standards include numeric and narrative criteria as well as a nondegradation policy that currently applies to the numeric criteria.

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular WQB-7 (MDEQ, 2002). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., life-long) exposures as well as through direct contact such as swimming.

The numeric aquatic life standards include chronic and acute values that are based on extensive laboratory studies including a wide variety of potentially affected species, a variety of life stages and durations of exposure. Chronic aquatic life standards are protective of long-term exposure to a parameter. The protection afforded by the chronic standards includes reproduction, early life stage survival and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective of short-term exposures to a parameter and are not to be exceeded.

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant" or an authorization to degrade must be granted by the Department. However under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard

are considered "high quality" for that parameter, and nondegradation policies apply to new or increased discharges to that the water body.

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface water quality standards. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a water body. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi and algae.

The standards applicable to the list of pollutants addressed in the Lake Helena watershed TPA are summarized, one-by-one, in the sections that follow.

Table B-1. Montana surface water classifications and designated beneficial uses.

Classification	Designated Uses
A-CLOSED CLASSIFICATION:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1 CLASSIFICATION:	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2 CLASSIFICATION:	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3 CLASSIFICATION:	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1 CLASSIFICATION:	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2 CLASSIFICATION:	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3 CLASSIFICATION:	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply.
I CLASSIFICATION:	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

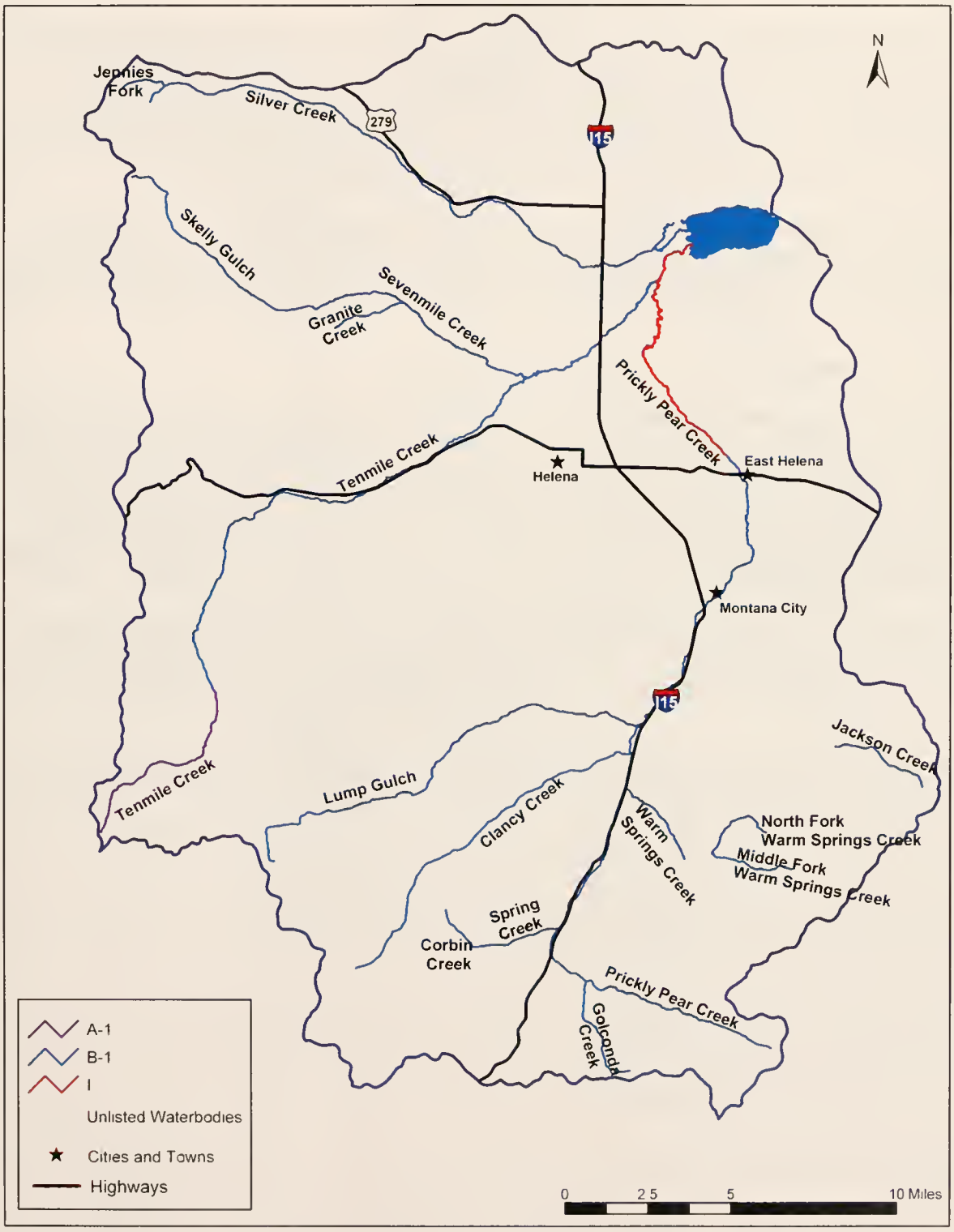


Figure B-1. Beneficial water use classifications in the Lake Helena watershed.

B.2.1 Nutrients

Most waters of Montana are protected from excessive nutrient concentrations by narrative standards. The exception is the Clark Fork River above the confluence with the Flathead River, where numeric water quality standards have been adopted. These standards are 300 µg/l for total nitrogen and 20 µg/l (upstream of the confluence with the Blackfoot River) and 39 µg/l (downstream of the confluence) for total phosphorus. A related standard has been established for algal biomass measured as chlorophyll *a*, which is 100 mg/m^2 as a summer mean concentration and 150 mg/m^2 as a maximum value.

The narrative standards applicable to nutrients elsewhere in Montana are contained in the General Prohibitions of the surface water quality standards (ARM 17.30.637 et seq.) Seq.,). The prohibition against the creation of "*conditions which produce undesirable aquatic life*" is generally the most relevant to nutrients.

B.2.2 Ammonia

The 30-day average (chronic) and 1-hour average (acute) criteria for total ammonia-nitrogen (expressed in mg/L as N) are calculated using equations in Circular WQB-7 (MDEQ, 2002). In addition, the highest four-day average concentration within any 30-day time period should not exceed 2.5 times the chronic criterion. The acute criterion in Circular WQB-7 is calculated on the basis of the instream pH value, while the chronic criterion is determined on the basis of pH and the presence or absence of early life stages of fish (MDEQ, 2002). The pH dependent acute and chronic criteria values are shown in Table B-2 and Table B-3 below.

Table B-2. pH dependent values of the CMC (acute criterion) ammonia standard (mg/L).

	CMC total Ammonia nitrogen (mg/L NH3 plus NH4-N)	
pH	Salmonids Present	Salmonids Absent
6.5	32.6	48.8
6.6	31.3	46.8
6.7	29.8	44.6
6.8	28.1	42.0
6.9	26.2	39.1
7.0	24.1	36.1
7.1	22.0	32.8
7.2	19.7	29.5
7.3	17.5	26.2
7.4	15.4	23.0
7.5	13.3	19.9
7.6	11.4	17.0
7.7	9.65	14.4
7.8	8.11	12.1
7.9	6.77	10.1

pH	CMC total Ammonia nitrogen (mg/L NH3 plus NH4-N)	
	Salmonids Present	Salmonids Absent
8.0	5.62	8.40
8.1	4.64	6.95
8.2	3.83	5.72
8.3	3.15	4.71
8.4	2.59	3.88
8.5	2.14	3.20
8.6	1.77	2.65
8.7	1.47	2.20
8.8	1.23	1.84
8.9	1.04	1.56
9.0	0.885	1.32

Table B-3. Temperature and pH dependent values of the CCC (chronic criterion) ammonia standard for early life stages present

Temperature, C																				
CCC for Fish Life Stages Present, total ammonia nitrogen (mg/l NH3-N plus NH4-N)											CCC for Fish Life Stages Absent, total ammonia nitrogen (mg/l NH3-N plus NH4-N)									
pH	0	14	16	18	20	22	24	26	28	30	0-7	8	9	10	11	12	13	14	15*	16*
6.5	6.7	6.7	6.1	5.3	4.7	4.1	3.6	3.2	2.8	2.5	10.8	10.1	9.51	8.9	8.4	7.8	7.4	6.9	6.5	6.1
6.6	6.6	6.6	6.1	5.3	4.6	4.1	3.6	3.1	2.8	2.4	10.7	10.0	9.4	8.8	8.2	7.7	7.2	6.8	6.4	6.0
6.7	6.4	6.4	6.0	5.2	4.5	4.0	3.5	3.1	2.7	2.4	10.5	9.81	9.2	8.6	8.1	7.6	7.1	6.7	6.3	5.9
6.8	6.3	6.3	5.9	5.0	4.4	3.9	3.4	3.0	2.6	2.3	10.2	9.58	8.98	8.4	7.9	7.4	6.9	6.5	6.1	5.7
6.9	6.1	6.1	5.7	4.9	4.3	3.8	3.3	2.9	2.6	2.3	9.93	9.31	8.73	8.2	7.7	7.2	6.8	6.3	5.9	5.6
7.0	5.9	5.9	5.6	4.7	4.2	3.7	3.2	2.8	2.5	2.2	9.6	9.0	8.43	7.9	7.4	6.9	6.5	6.1	5.7	5.4
7.1	5.7	6.7	5.4	4.5	4.0	3.5	3.1	2.7	2.4	2.1	9.2	8.6	8.1	7.6	7.1	6.7	6.3	5.9	5.5	5.2

Temperature, C																				
CCC for Fish Life Stages Present, total ammonia nitrogen (mg/l NH3-N plus NH4-N)											CCC for Fish Life Stages Absent, total ammonia nitrogen (mg/l NH3-N plus NH4-N)									
7.2	5.4	5.4	5.2	4.3	3.8	3.3	2.9	2.6	2.3	2.0	8.8	8.2	7.7	7.2	6.8	6.3	5.9	5.6	5.2	4.9
7.3	5.1	5.1	5.0	4.1	3.6	3.1	2.8	2.4	2.1	1.9	8.24	7.73	7.25	6.8	6.4	6.0	5.6	5.3	4.9	4.6
7.4	4.8	4.7	4.6	3.8	3.3	2.9	2.6	2.3	2.0	1.7	7.7	7.21	6.76	6.3	5.9	5.6	5.2	4.9	4.6	4.3
7.5	4.4	4.4	4.3	3.5	3.1	2.7	2.4	2.1	1.8	1.6	7.1	6.64	6.23	5.8	5.5	5.1	4.8	4.5	4.23	3.97
7.6	4.0	4.0	4.0	3.2	2.8	2.5	2.2	1.9	1.7	1.5	6.5	6.05	5.67	5.3	5.0	4.7	4.4	4.1	3.85	3.61
7.7	3.6	3.6	3.6	2.9	2.5	2.2	1.9	1.7	1.5	1.3	5.81	5.45	5.11	4.8	4.5	4.2	4.0	3.7	3.47	3.25
7.8	3.2	3.2	3.3	2.5	2.2	2.0	1.7	1.5	1.3	1.2	5.17	4.84	4.54	4.3	4.0	3.7	3.5	3.3	3.1	2.9
7.9	2.8	2.8	2.9	2.2	2.0	1.7	1.5	1.3	1.2	1.0	4.54	4.26	3.99	3.7	3.5	3.3	3.1	2.9	2.7	2.54
8.0	2.4	2.4	2.2	2.0	1.7	1.5	1.3	1.2	1.0	0.9	3.95	3.70	3.47	3.3	3.1	2.9	2.7	2.5	2.4	2.21
8.1	2.1	2.1	2.0	1.7	1.5	1.3	1.1	1.0	0.9	0.8	3.41	3.19	2.99	2.8	2.6	2.5	2.3	2.2	2.03	1.91
8.2	1.8	1.8	1.6	1.4	1.3	1.1	1.0	0.9	0.8	0.7	2.91	2.73	2.56	2.4	2.3	2.1	2.0	1.9	1.74	1.63
8.3	1.5	1.5	1.4	1.2	1.1	1.0	0.8	0.7	0.6	0.6	2.47	2.32	2.18	2.0	1.9	1.8	1.7	1.6	1.5	1.4
8.4	1.3	1.3	1.2	1.0	1.0	0.8	0.7	0.6	0.5	0.5	2.09	1.96	1.84	1.7	1.6	1.5	1.4	1.3	1.3	1.2
8.5	1.1	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	1.77	1.66	1.55	1.5	1.4	1.3	1.2	1.1	1.1	0.99
8.6	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.3	1.49	1.4	1.31	1.2	1.2	1.1	1.0	1.0	0.89	0.84
8.7	0.8	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	1.26	1.18	1.11	1.0	1.0	0.9	0.9	0.8	0.75	0.71

Temperature, C																				
CCC for Fish Life Stages Present, total ammonia nitrogen (mg/l NH3-N plus NH4-N)											CCC for Fish Life Stages Absent, total ammonia nitrogen (mg/l NH3-N plus NH4-N)									
8.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	1.07	1.01	0.94	0.9	0.8	0.8	0.7	0.7	0.6	0.6
8.9	0.6	0.6	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.92	0.86	0.81	0.8	0.7	0.7	0.6	0.6	0.5	0.5
9.0	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.79	0.74	0.69	0.7	0.6	0.6	0.5	0.5	0.5	0.4

*At 15 C and above, the criterion for fish ELS absent is the same as the criterion for fish ELS present

B.2.3 Dissolved Oxygen

The freshwater aquatic life standards for dissolved oxygen are presented in Table B-4. A table of fish spawning times and schedule for the presence of early life stages of fish are likely may be found at http://www.deq.state.mt.us/wqinfo/Standards/SpawningTimesFWP.pdf.

Table B-4. Aquatic life standards for dissolved oxygen (mg/L).

Time Period	Use Classes A-1 and B-1		Use Class I	
	Early Life Stages[a]	Other Life Stages	Early Life Stages	Other Life Stages
30-day average	NA	6.5	NA	5.5
7-day average	9.5 (6.5)	NA	6.0	NA
7-day average minimum	NA	5.0	NA	4.0
1-day minimum	8.0 (5.0)	4.0	5.0	3.0

[a]These are water column concentrations recommended to achieve the required intergravel DO concentrations shown in parentheses. For species that have early life stages exposed directly to the water column, the figures in parentheses apply.

B.2.4 Sediment

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in Table B-5. The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a reference condition that reflects a water body's greatest potential for water quality given current and historic land use activities, where all reasonable land, soil, and water conservation practices have been applied (see definitions in Table B-5).

Table B-5. Applicable rules for sediment related pollutants.

Rule(s)	Standard
17.30.623(2)	No person may violate the following specific water quality standards for waters classified B-1.
17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will.
17.30.637(1)(a)	Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines.
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
	The maximum allowable increase above naturally occurring turbidity is: 0 NTU for A-closed; 5 NTU for A-1, B-1, and C-1; 10 NTU for B-2, C-2, and C-3)
17.30.602(17)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
17.30.602(21)	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.

B.2.5 Metals

Numeric criteria for metals in Montana include specific standards for the protection of both aquatic life and human health. As described earlier, both acute and chronic criteria have been established for the protection of aquatic life. The criteria for some metals vary according to the hardness of the water. The standards for cadmium, copper, chromium (III), lead, nickel, silver and zinc vary according to the hardness of the water. Theses standards have an inverse relationship to toxicity (decreasing hardness causes increased toxicity). The applicable numeric criteria for the metals of concern in the Lake Helena watershed TPA are presented in Table B-6.

It should be noted that recent studies have indicated some metals concentrations vary through out the day because of diel pH and alkalinity changes. In some cases the variation can cross the standard threshold (both ways) for a metal. Montana water quality standards are not time of day dependent.

Table B-6. Montana numeric surface water quality standards for metals.

Parameter	Aquatic Life (acute) (µL)[a]	Aquatic Life (chronic) (µL)[b]	Human Health (µL)[a]
Arsenic (TR)	340	150	18 [d]
Cadmium (TR)	1.05 @ 50 mg/L hardness[c]	0.16 @ 50 mg/L hardness[c]	5
Copper (TR)	7.3 @ 50 mg/L hardness[c]	5.2 @ 50 mg/L hardness[c]	1,300
Lead (TR)	82 @ 100 mg/L hardness[c]	3.2 @ 100 mg/L hardness[c]	15
Zinc (TR)	67 @ 50 mg/L hardness[c]	67 @ 50 mg/L hardness[c]	2,000

[a]Maximum allowable concentration.
[b]No 4-day (96-hour) or longer period average concentration may exceed these values.
[c]Standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L).
[d] Human health standard for arsenic is currently 18 ug/L, but will change to 10 µg/L in 2006.
Note: TR – total recoverable.

B.2.6 pH

Montana's standards set restrictions on induced variations in hydrogen ion concentration, or pH, inorder to protect fish and aquatic life as well as other beneficial uses.

For waters classified as A-1 or B-1, the maximum allowable change in pH within the range of 6.5 to 8.5 must be less than 0.5 pH units. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be mainatiend above 7.0 (ARM 17.30.622(c), ARM 17.30.623(c)).

For waters classified as I, pH must be maintained within the range of 6.5 to 9.5 (ARM 17.30.628(c)).

B.2.7 Water Temperature

Montana's temperature standards were originally developed to address situations associated with point source discharges, making them somewhat awkward to apply when dealing with primarily nonpoint source issues. In practical terms, the temperature standards address a maximum allowable increase above "naturally occurring" temperatures to protect the existing temperature regime for fish and aquatic life. Additionally, Montana's temperature standards address the maximum allowable rate at which temperature increases or decreases can occur in order to avoid fish and aquatic life temperature shock.

For waters classified as A-1 or B-1, the maximum allowable increase over naturally occurring temperature (if the naturally occurring temperature is less than 67° Fahrenheit) is 1° (F) and the rate of change cannot exceed 2°F per hour. If the natural occurring temperature is greater than 67° F, the maximum allowable increase is 0.5° F (ARM 17.30.622(e), ARM 17.30.623(e)).

For waters classified I, no increase in naturally occurring temperature is allowed which will or is likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife (ARM 17.30.628(e)).

B.2.8 Salinity/TDS/Chlorides

Montana currently does not have numeric standards for chlorides. USEPA recommends chloride standards for streams and rivers based on the aquatic toxicity of plant, fish, and invertebrate species (USEPA, 1999). USEPA recommends an acute standard of 860 mg/L and a chronic standard of 230 mg/L. These standards are proposed here as target values for Lake Helena watershed streams (Table B-7).

Table B-7. Proposed chloride target values for the Lake Helena watershed.

Targets	Threshold
Chloride Concentration (max)	< 860 mg/L
Chloride Concentration (avg)	< 230 mg/L

B.2.9 Priority Organics

Silver Creek was listed as impaired because of priority organics on the Montana 303(d) list. Additional information from Montana DEQ identified dichlorodiphenyl-dichloroethylene (DDE) as the priority organic pollutant of concern.

DDE is a breakdown product of DDT (dichlorodiphenyltrichloroethane), which was once widely used as a pesticide throughout the United States. Although banned, DDT and DDE still exist in the atmosphere and soils. Both bond strongly to soils and breakdown over a period of 2 to 15 years (ATSDR, 2002). DDE is listed by USEPA as a "probable human carcinogen", and has been shown to cause reproductive and liver damage in avian species (USEPA, 1980). The Montana water quality standard for DDE is a maximum of 0.0059 ug/L to protect human health, and this standard is also protective of aquatic life.

Appendix C: Preliminary Source Assessment

A Preliminary Assessment of Sources Contributing to Water Quality Impairments in 303(d)-Listed Segments of the Lake Helena TMDL Planning Area

C.1.0 INTRODUCTION

The purpose of this preliminary source assessment is to provide a general characterization of the types, locations, and severity of pollution sources contributing to water quality impairment in 303(d)-listed segments of the Lake Helena TMDL Planning Area (TPA). The array of pollutant sources affecting streams in the Lake Helena TPA are a result of historic and current land use practices, as well as natural processes. The magnitude of problems range from high to low severity and are found upslope from, adjacent to, and within the stream channels. Special note should be made to the fact that all observations were made during dry weather conditions. Thus, wet-weather conditions were not documented. This information is intended to provide the basis for designing a more rigorous and quantitative pollution source assessment approach for the Lake Helena TPA.

C.2.0 METHODS

The 2003 preliminary source assessment for the Lake Helena TPA combines results from a field visual survey, field monitoring for chemical, physical, and biological water quality variables, and an aerial photo assessment. While pre-existing information was also considered within the context of this study, no attempts have been made to correlate these findings with the information and conclusions presented in the Montana 303(d) List. As such, this effort represents a more or less independent appraisal of water quality impacts and their sources of origin in each of the Lake Helena TPA 303(d) segments.

C.2.1 Field Source Assessment

The field source assessment was conducted as a joint effort between the Helena National Forest (HNF), the Montana Office of the U.S. EPA, and its contractors Tetra Tech, Inc. and Land & Water Consulting, Inc. A database dictionary was developed that established standardized codes for collection of GPS source data in the field (Part 2). The HNF field crew preformed surveys on the HNF portions of 303(d)-listed streams downstream to the forest administrative boundary. The Tetra Tech/Land & Water field crew was responsible for performing surveys on all other 303(d)-listed streams.

Both the HNF and Tetra Tech/Land & Water field crews used similar techniques to document source assessment information. Digital photos were taken of all significant source areas and these were catalogued by an associated GPS site identifier or by the applicable listed segment. Source sites were located in the field using GPS receivers set to the WGS 84 Datum. All photos and GPS locations were described in a field notebook. GPS source area sites were assigned data dictionary codes for pollution cause, pollution source, and relative severity ratings that described a source's potential for contributing pollution loading to the specific 303(d)-listed receiving water body. Oftentimes, the documented GPS sites would include more than one cause and source of impairment.

Due to private property constraints, the Tetra Tech/Land & Water field crew was limited to inventorying the listed streams from available access points and road networks. Field photographs and GPS pollution source information were collected for all 303(d)-listed streams except Golconda Creek and Jackson Creek, where access was not readily available. Field photos were taken of Lake Helena, but a focused

pollution source inventory of the shoreline area was not performed. Some of the source location information provided by the HNF was collected as part of a focused road sediment study of the upper Prickly Pear Creek, North Fork of Warm Springs Creek, upper Lump Gulch, Tenmile Creek, and Skelly Gulch drainages.

After field data collection was completed, the HNF and Tetra Tech/Land & Water data were consolidated. All digital photos were compiled and a photo log was created listing photo identifications and descriptions, GPS site identifiers (if associated with the photos), and applicable Montana 305(b) water body numbers (Part 2). The GPS site locations and field notes were used to create a standardized GIS data layer. A map of the GPS source assessment sites is located in Figure 1.

C.2.2 Field Monitoring

From late June through early September 2003, suspected impaired streams within the Lake Helena TPA were visited to collect chemical, physical, and biological data. Monitoring was performed on each of 31 stream or lake segments, including 22 303(d)-listed segments and nine least-impaired reference stream segments. Sampling was conducted at least twice on most of the 303(d) segments, with as many as four visits to some sites. Visual field observations and sampling results, including any apparent violations of surface water quality standards, were considered when developing this source assessment report.

C.2.3 Aerial Photo Inventory

An air photo analysis was completed for the 303(d)-listed streams in the Lake Helena TPA. Current stereo-pair, aerial photos were acquired from the Helena National Forest and the Montana Department of Transportation. In a few instances, USGS digital orthophoto quadrangle maps were used to make observations where coverage at an adequate scale and time frame was unavailable. Aerial photos varied from true color to black and white with dates ranging from 1995 to 1999, and scales were either 1:15,840 or 1: 24,000 (Part 3). For lower Clancy Creek, photo interpretation was performed using 1980 black and white, 1:6,000 stereo-pair aerial photographs acquired from the Montana Department of Transportation.

Equipment used for the air photo inventory included a stereoscope, light table, scale, and digitizing planimeter. Digital 1:24,000-scale USGS topographic maps and one-meter resolution orthophoto quadrangle maps were assembled in a GIS to aid with the map measurements and data interpretation. The 303(d)-listed streams were broken into reaches on the basis of land ownership, topography, and land use. For each stream reach, observations were recorded for the following variables: stream length, land ownership, land use, channel slope (map), stream sinuosity, riparian buffer widths, canopy density, channel stability, road encroachment, stream channelization, road crossings, irrigation diversions and return flows, sediment sources, and general comments (Part 3).

Stream length, sinuosity, riparian buffers, road encroachment, and channelization were measured from the aerial photos using a Tamaya Super Planix β digitizing planimeter. Stream length was measured along the thalweg, while stream sinuosity was derived from the thalweg length divided by the valley length. Riparian buffer width, defined as the average horizontal width of riparian vegetation, was measured in at least five locations per stream reach to generate a representative range of buffer widths. Road encroachment measured the length of stream where a road was located within 100 feet of the stream, but was not necessarily altering its natural course. Channelization measured the length of stream course that had been straightened due to anthropogenic activities, including roads.

Land ownership was calculated with GIS along each stream course using the 1:100,000 BLM ownership layer for Montana. Bed slope was also calculated in a GIS from the USGS 1:24,000 digital topographic maps. Canopy density was estimated using a forest survey canopy density scale. Other characteristics,

such as land use, lateral and vertical channel stability (including areas of channel aggradation and incisement), road crossings, irrigation diversions and return flows, and sediment sources were inferred from the photos, and are representative of features that were visible at the scale of the photo.

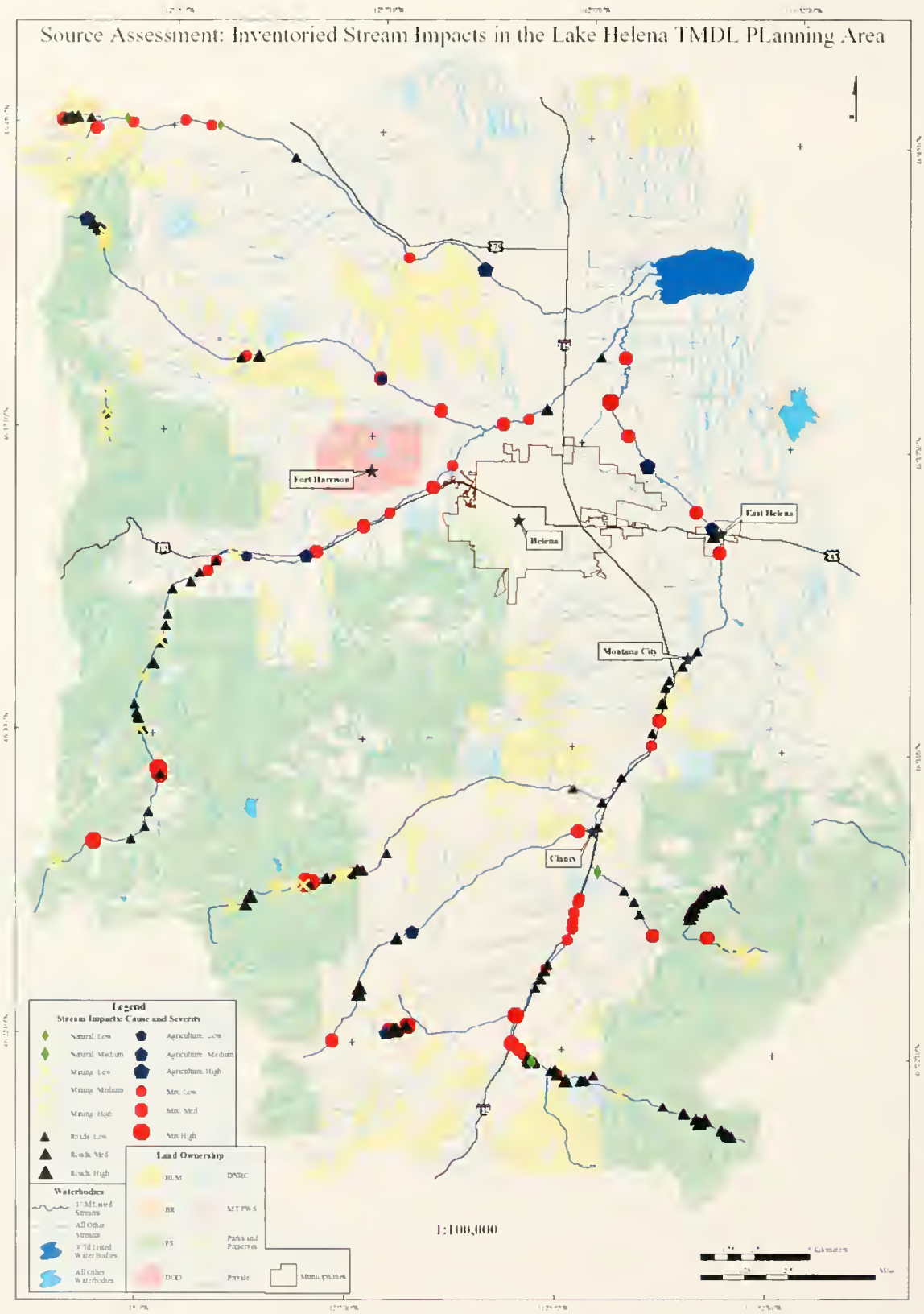


Figure C-1. Results of the GPS field survey.

C.3.0 RESULTS

The following sections are narrative source assessment summaries for the 303(d)-listed segments in the Lake Helena TPA. The summaries combine observations from the field source assessment, the 2003 water quality monitoring, the aerial photo inventory, and information from relevant GIS data layers (e.g. geology, soils, locations of abandoned mines, etc.). The summaries have been organized by sub-watershed, beginning with Prickly Pear Creek and its tributaries, and followed by the Tenmile and Silver Creek drainages. Lake Helena appears last in the narrative. A condensed summary of the findings is contained in Part 4 to this report.

C.3.1 Prickly Pear Creek Drainage

C.3.1.1 Prickly Pear Creek (headwaters to Spring Creek) MT41I006_060

Stream segment MT41I006_060 is approximately 8.5 miles in length and is impacted by sediment, metals, and habitat and channel alterations, and flow alteration. Road maintenance and runoff, agricultural non-point sources (grazing), and diffuse sources associated with rural home sites contribute sediment to the stream. Natural sediment sources associated with the highly erosive granitic geology of the watershed are also apparent. Golconda Creek and possibly historic instream mining sources contribute metals. Historic placer mining and associated stream channelization have altered stream morphology and hydrology. Additional channelization is associated with forest and county roads and the I-15 corridor. Dewatering of the stream occurs in the lower end of the segment. This segment will be reviewed on the basis of ownership.

The headwaters of this stream flow through lands administered by the Helena National Forest (HNF). From its source to the HNF boundary, a distance of about four miles, the stream goes from a Rosgen stream type A to B, with a few less confined sections (C). The HNF management strategy for this watershed falls on the dividing line between the roaded and unroaded portions of the Elkhorn Management Unit. The land is managed for mountain goat and elk habitat, as well as other wildlife habitat. For the roaded unit, the land is also managed for livestock grazing and habitat enhancing timber harvests. Within the HNF administrative boundary, there are old patented mining claims surrounding the creek which are used for dispersed, private home sites. During the air photo assessment, extensive riparian buffers and moderate road encroachment were observed. The HNF field survey team gave the stream a rating of "proper functioning condition", but noted some excess sediment deposition. GPS source assessment sites on the HNF mainly consisted of road sediment delivery points from the Tizer Lakes Road, which is an unimproved four wheel-drive road. An incidence of channel incision was observed at the site of an old mining claim.

Prickly Pear Creek flows through mostly private property in the 4.5 mile segment from the HNF boundary to the Spring Creek confluence. The Rosgen stream type changes between B and C, with channel alterations in the lower portion of the segment. During the air photo assessment, variable width riparian buffers, moderate road encroachment from the Tizer Lake Road, and channelization associated with the I-15 corridor were observed. The primary land use is rural housing. GPS source assessment features on this stretch of the stream included problem culverts, road sediment delivery points, and an overgrazed pasture with bank trampling, removal of riparian vegetation and noxious weed infestations. Major stream impairments begin at the site of the old placer gold dredge operation, just above I-15, which also corresponds with the grazing site. The stream has become incised, overly widened, and straightened as a result of the historic placer mining. Stream dewatering occurs just below the confluence with Beavertown Creek, where the Montana Tunnels Mine makes an inter-basin transfer to holding ponds on Spring Creek. During July of 2003, Prickly Pear at Spring Creek was almost dry (< 1 cfs). The Tetra

Tech/Land & Water field crew noted stranded juvenile trout in stagnant pools near the Spring Creek confluence.

C.3.1.2 Prickly Pear Creek (from Spring Creek to Lump Gulch) MT41I006_050

Stream segment MT41I006_050 is approximately seven miles in length and is impacted by sediment, habitat and channel alterations, metals, and flow alteration. Road maintenance and runoff, tributary streams, in-channel sources, and diffuse non-point sources associated with rural housing and grazing contribute sediment to the stream. Channelization from roads (mainly I-15) and historic placer mining activities have altered stream morphology and altered the hydrology. Tributary streams, such as Golconda Creek, Spring Creek, Clancy Creek and Warm Springs Creek, contribute metals contaminants. Hydromodification and dewatering problems are associated with industrial diversions from Prickly Pear Creek and Spring Creek for the Montana Tunnels Mine, and possibly agricultural diversions from the main stem and the various tributaries.

Private property lines the majority of Prickly Pear Creek from the confluence with Spring Creek to Lump Gulch. In many stretches, the stream does not conform to any particular Rosgen stream type, but has some characteristics of C and F channels. During the air photo assessment, 91 percent of the length of this segment was affected by channelization, with the width of the riparian buffer area corresponding to distance from roads. The primary land use adjacent to the stream is as a transportation corridor. Private developments are more frequent in this segment than in the headwaters segment, with the appearance of small subdivisions and more structures in the floodplain. In many areas, gravel placer tailings piles line the banks and historic floodplain of the stream (and this material is also associated with the I-15 road berm). In some places, high transmissivity of the placer tailings deposits has created wetland environments due to shallow subsurface flow and placement in areas of former stream channels. During field sampling, spring seeps were noted entering Prickly Pear Creek from the tailings piles.

A field survey conducted by the Tetra Tech/Land & Water team in summer 2003 in the reach of Prickly Pear Creek below Alhambra yielded a rating of "non-functional", but the field team noted that the riparian area had moist soils and vigorous willow growth. GPS source assessment features noted along Prickly Pear Creek from Spring Creek to Lump Gulch included extensive channelization associated with roads, sediment delivery points, channel incision, removal of riparian vegetation, poorly managed grazing lands, placer tailings, noxious weed infestations, and suspected wastewater seepage from an outhouse in the floodplain.

C.3.1.3 Prickly Pear Creek (from Lump Gulch to Wylie Drive) MT41I006_040

Stream segment MT41I006_040 is approximately 11 miles in length and is impacted by sediment, habitat and channel alterations, metals, and flow alteration. Road maintenance and runoff, tributary streams, and in-channel and upstream sources contribute sediment to the stream. Channelization from roads (I-15, the railroad, subdivision roads, and East Helena) and mining activities (historic placer and recent ASARCO activities) have altered stream morphology and possibly hydrology. Upstream sources, Lump Gulch, and mining activities contribute metals contaminants. Diffuse sediment sources associated with subdivisions, rural housing, and agricultural non-point sources also affect the stream. A diversion dam at the ASARCO smelter has altered stream flows and makes fish passage difficult. Agricultural water diversions also modify stream flows.

This segment encounters many of the same problems as the upstream segment, with a notable increase in development pressures. Private property lines the majority of the stream from the confluence with Lump Gulch to Wylie Drive. In many stretches, the stream does not conform to a particular Rosgen stream type, but has some characteristics of C and F channels. During the air photo assessment, 63 percent of the stream segment was observed to be affected by channelization, with the width of riparian buffers again corresponding to distance from roads. The primary land use adjacent to the stream is as a transportation corridor, with many upslope subdivisions in the beginning of this segment and the town of East Helena near the end of the segment. Gravel bars were visible in the stretch below Montana City, and extensive channel alterations were visible from the confluence with Holmes Gulch and extending downstream through the town of East Helena. Before crossing Wylie Drive, Prickly Pear Creek splits into two channels. The cause of the splitting is thought to be unnatural, and during low flow the stream only flows in the left channel. The right channel may serve as a high water bypass for flood control purposes.

A field survey was conducted by the Tetra Tech/Land & Water team on the segment of Prickly Pear Creek below McClellan Creek in summer 2003. The field team assigned a rating of "functional-at risk", citing upstream conditions and excessive sediment deposition as sources of impairment. GPS source assessment features recorded in the segment of Prickly Pear Creek from Lump Gulch to Wylie Drive included road channelization, variously caused sediment delivery points, stream bank alterations (riprap, diking), removal of riparian vegetation, sediment depositional reaches, suspected wastewater seepage from individual septic systems, an irrigation diversion, and noxious weeds. Healthy intermittent riparian conditions and some good fish habitat components were noted in reaches above the Sleepy Hollow Estates subdivision and below the confluence with McClellan Creek. The ASARCO smelter has a dam just above East Helena, which has probably contributed to an overall decrease in stream gradient and an increase in channel embeddedness. In summer 2003, the stream was documented as having a flow of less than 0.5 cfs below an irrigation diversion located between East Helena and Wylie Drive.

C.3.1.4 Prickly Pear Creek (Wylie Drive to Helena WWTP Discharge) MT41I006_030

Stream segment MT41I006_030 is approximately five miles in length and is impacted by sediment, habitat and channel alterations, metals, nutrients, and flow alteration. Road maintenance and runoff, upstream sources, and raw stream banks and other in-channel sources contribute sediment to the stream. Channelization associated with irrigation diversions, mining activities (gravel pits), and agricultural operations has altered stream morphology. Upstream sources contribute metals contaminants. Agricultural non-point sources probably contribute nutrients. Diffuse sources of sediment and nutrients from grazing, subdivisions, and rural housing may also affect the stream. Agricultural water diversions severely deplete stream flows in summer.

Private property borders the entire length of this stream segment. In channelized stretches, the stream does not conform to a particular Rosgen stream type. After passing the Canyon Ferry Road crossing, the

stream gains flow from groundwater sources and exhibits characteristics of Rosgen C and F channels. During the air photo assessment, it was noted that 30 percent of the segment was affected to some degree by channelization. Riparian belt widths are variable depending on land management practices. The primary land uses adjacent to the stream are agricultural, including hay fields and pasture. Gravel bars were visible in the stretch where the stream flows by a large gravel mining operation. Extensive channel alterations were noted from the just before the Helena Valley Irrigation Canal to the Canyon Ferry Road crossing.

The Tetra Tech/Land & Water field team investigated two portions of this segment: below Wylie Drive and below Canyon Ferry Drive. At both sites, the field team gave the stream a rating of "non-functional". Perhaps the most detrimental impact is stream dewatering. In 2003, irrigation withdrawals left a dry streambed at Canyon Ferry Road from early July thru September. Below Canyon Ferry Road, the stream regained water from groundwater discharge and this comprised the majority of flow in the stream. During July 2003, in reaches of Prickly Pear Creek near Canyon Ferry Road and near and below York Road, numerous young trout and non-game fish were observed stranded in isolated pools. Also noted in Prickly Pear Creek from Wylie Drive to the Helena wastewater treatment plant outfall were poor riparian conditions, grazing impacts, and a metallic sheen on the water surface. GPS source assessment features included a dry streambed, removal of riparian vegetation, poorly managed grazing lands, and road sediment delivery points.

C.3.1.5 Prickly Pear Creek (Helena WWTP discharge to Lake Helena) MT41I006_020

Stream segment MT41I006_020 is approximately six miles in length and is impacted by sediment, habitat and channel alterations, metals, nutrients, and flow alteration. Road maintenance and runoff, numerous upstream sources, unvegetated stream banks, and various agricultural non-point sources contribute sediment to the stream. Channelization associated with roads and agricultural operations have altered stream morphology. Upstream sources contribute metals contaminants. Irrigation return flows, grazing practices, a mixture of other agricultural non-point sources, upstream sources, and the Helena Waste Water Treatment Plant (WWTP) contribute nutrients to this segment of Prickly Pear Creek. Diffuse sediment and nutrient sources from rural housing may also affect the stream. Dewatering of the channel upstream influences flow dynamics and bank stabilization in this segment.

Private property encompasses the entire length of this stream segment, with primarily agricultural land uses (irrigated hay fields and pasture) and some rural housing adjacent to the stream. The stream exhibits characteristics of Rosgen C and F channels. The Helena WWTP outfall and groundwater discharges contribute to stream flow in this segment of lower Prickly Pear Creek. Riparian belt widths were variable depending on land uses and land management practices. Below the confluence with Tenmile Creek, failing stream banks were evident in areas with little to no riparian vegetation. Riparian condition and stream bank stability were also poor in the reach just below the Helena WWTP discharge. Prickly Pear Creek discharges into Lake Helena in a natural deltaic form with extensive sediment deposition visible.

A field survey was conducted by the Tetra Tech/Land & Water team on a reach of the stream immediately above the Sierra Road crossing. The field team gave the stream a rating of "non-functional". A lack of diverse and woody riparian vegetation was noted. The stream was heavily riprapped and access to a natural floodplain has been nearly eliminated. GPS source assessment features included irrigation return flows, the discharge from the Helena WWTP, removal of riparian vegetation, poorly managed grazing lands, various agricultural non-point sources, stream channelization, stream bank alterations, and sediment delivery points.

C.3.1.6 Golconda Creek (headwaters to the mouth) MT41I006 070

Stream segment MT41I006_070 is approximately 3.5 miles in length and is impacted by sediment and metals. Road maintenance and runoff, impaired tributary streams, and historical lode mining and milling activities contribute sediment. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates and represents a natural source of impairment. Historic hard rock mining operations in the watershed contribute metals.

Most of Golconda Creek flows through Bureau of Land Management (BLM) managed lands with about a half-mile of private property near the stream's mouth. On BLM lands, the area is managed for a deferred rotation grazing system. There is dispersed housing on the lower privately owned segment. The stream goes from a Rosgen stream type Aa to B, with a few less confined sections (C). During the air photo assessment, a healthy riparian buffer area was noted but with moderate road encroachment in some areas. Old mining and timber harvest operations (clear cuts) were observed in tributary drainages to the west of the main stem of Golconda Creek. High road densities were also noted here, and significant mining disturbances were present on private lands near the main stem.

The Tetra Tech/Land & Water field team performed a survey on a portion of this segment about one-third of a mile below the BLM boundary. The field team assigned a rating of "proper functioning condition". Sedimentation was noted in the stream, and private development has occurred within the floodplain near the stream's mouth. Due to access constraints, no source assessment features were documented with the GPS. The State of Montana's inventory of mine sites shows three mines in the drainage: Buckeye, Golconda, and Big Chief, the latter of which is in closest proximity to the stream and once produced lead, zinc, gold, and silver.

C.3.1.7 Corbin Creek (headwaters to the mouth) MT41I006_090

Stream segment MT41I006_090 is approximately 2.5 miles in length and is severely impacted by sediment, habitat and channel alterations, metals, and possibly flow alteration. Road maintenance and runoff and unvegetated stream banks and floodplain areas contribute sediment to the stream. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates. Historic placer mining, mine reclamation activities, and livestock grazing have altered stream morphology, and possibly hydrology and stream flows. Historic hard rock mining operations in the watershed contribute metals.

Most of this stream segment flows through private land. The primary land use is pasture, with a handful of homes located at the old Corbin town site near Corbin Creek's confluence with Spring Creek. Corbin Creek transforms from a Rosgen stream type Aa to sections of altered B and C. Historic placer mining and recent reclamation work have incised, widened, and straightened the channel. The full benefits of the reclamation have yet to take effect because vegetation has not yet become well established. During the air photo assessment, moderate road encroachment was observed. A significant riparian zone was only noted in the headwaters. Major road sediment sources were noted in the headwaters area, together with significant riparian grazing impacts. A short distance below the headwaters and below the first road crossing, the stream exhibits exposed banks, excessive sedimentation, and little to no riparian vegetation. The stream is channelized through the town of Corbin.

The Tetra Tech/Land & Water field team conducted a survey on a portion of this segment above the town of Corbin during summer 2003. The field team gave the stream a rating of "non-functional". Numerous road sediment delivery points were documented with the GPS, along with channel incisement, bank erosion, livestock trampled banks, and weed infestations. Another issue is that this stream at least periodically goes dry before reaching the mouth. This is may be related to surface flow losses to groundwater accelerated by the granitic geology. Another factor may be the extensive water collection and routing system installed as a part of recent mine reclamation activities. In early July 2003, a monitoring site located near the mouth was dry and sampling had to be conducted about one-half mile

upstream. By late July, this upper site had also gone dry and only a trickle of flow remained at upstream locations.

C.3.1.8 Spring Creek (Corbin Creek to the mouth) MT41I006_080

Stream segment MT41I006_080 is approximately two miles in length and is severely impacted by sediment, habitat and channel alterations, metals, and flow alteration. Road maintenance and runoff, unvegetated stream banks, streamside mill tailings deposits near Jefferson City, and riparian grazing may all contribute sediment to the stream. Historic lode mining, road construction, mine reclamation work, inter-basin water transfers from Prickly Pear Creek, water withdrawals for the Montana Tunnels Mine, and livestock grazing have altered stream morphology and aquatic habitat. Flow from Corbin Creek and historic mill tailings deposits in the watershed contribute metals. Diffuse sediment and nutrient sources associated with rural home sites may also affect the stream. More localized impacts are present along Spring Creek in the town of Jefferson City.

Private property lines the entire length of the stream segment. The primary land uses are pasture and rural housing. The stream does not conform to any particular Rosgen stream type, but has some characteristics of F and G channels. Historic mining and milling activities and reclamation work in the Corbin Flats area have straightened the channel. The Montana Tunnels Mine's reclamation work reshaped the channel into a ditch with virtually no meanders. Just above where the 303(d)-listed segment begins on Spring Creek, the Montana Tunnels Mine has a holding pond and water transfer station for pumping water up to their operation. This has affected Spring Creek in two ways: 1) water from Prickly Pear Creek is periodically added to Spring Creek at this location, and 2) water is withdrawn from Spring Creek leading to downstream dewatering problems. Spring Creek has been channelized and is severely incised at its mouth on Prickly Pear Creek. Contributing factors are I-15 construction and historical placer mining on this section of Prickly Pear Creek and possibly Spring Creek.

During the air photo assessment, minor road encroachment was noted along Spring Creek. Virtually 100 percent of the stream has been channelized due to historical mine related activities and, more recently, mine reclamation work. Spring Creek is also channelized and bermed through the town of Jefferson City. The dike material appears to be composed of old mine or mill tailings. Riparian buffers are virtually absent.

The Tetra Tech/Land & Water field team performed a field investigation on a portion of Spring Creek above Jefferson City in summer 2003. The field team rated the stream as "non-functional". A field based GPS source assessment survey documented channelization, road sediment delivery points, riparian grazing impacts, and channel incision. During summer field sampling, head cutting was observed near the stream's mouth. The creek channel went dry near the mouth for a few weeks in early August of 2003.

C.3.1.9 Middle Fork Warm Springs Creek (headwaters to the mouth) MT41I006_100

Stream segment MT41I006_100 is approximately 2.5 miles in length and is impacted by sediment, metals, and habitat and channel alterations. Road maintenance and runoff, unvegetated stream banks, mine tailings, and disturbed tributary streams contribute sediment. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates. Historic hard rock mining operations in the watershed contribute metals. Historic mining activities have also altered stream morphology.

Most of the stream flows through a section of the HNF Elkhorn Management Unit. This area of the Elkhorns is managed for big game habitat and optimal water quality. There is also some private land in the upper portion of the watershed that has been heavily logged. The stream goes from a Rosgen stream type Aa to an altered B in this segment with a few less confined sections (C). Historic placer mining and

failure of a historic mining dam have caused channel incisement. During the air photo assessment, road encroachment was observed along 56 percent of the segment. Riparian belt widths were fairly wide, except where limited by road encroachment. A large tailings mine dump was observed in the middle of the stream that prevented vegetation growth and disrupted the natural channel. Water in upper Middle Fork Warm Springs Creek had a metallic sheen suggesting the presence of metals ions. The state's inventory of mines shows twelve mines in this sub-watershed. In addition to the twelve mine sites, there are two high priority abandoned mine sites slated for cleanup. Both of these high priority sites encompass part of the upper stream course. Heavy logging was visible on the private lands above the north side of the stream.

The HNF field survey team gave the stream a rating of "functional-at risk", noting that the steam is recovering from the effects of mining. Excessive sediment deposition was noted in the stream from eroding banks and road runoff. The HNF GPS pollution source inventory documented road sediment delivery points, channel incision, and mine tailings and waste rock piles. The Middle Fork experiences greater flow volumes than the North Fork.

C.3.1.10 North Fork Warm Springs Creek (headwaters to the mouth) MT411006_180

Stream segment MT411006_180 is approximately two miles in length and is impacted by sediment, metals, and habitat alterations. Road maintenance and runoff contribute sediment to the stream. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates. Historic hard rock mining operations in the watershed contribute metals.

The majority of the stream flows through a section of the HNF Elkhorn Management Unit. This area of the Elkhorns is managed for big game habitat and optimal water quality. The stream also flows through a section of private land that has some dispersed housing along the creek. The stream transforms from a Rosgen stream type Aa to Ba through this reach with a less confined section (C) in the private section of the stream. During the air photo assessment extensive riparian buffers were noted on the HNF, but belt widths narrowed and became sparse along the section of private land. Moderate road encroachment was observed. The state's inventory of mines shows two mines close to the headwaters and one mine close to the mouth (all hard rock mines).

The HNF field survey team gave the stream a rating of "functional-at risk", citing excess sediment as the cause. The HNF GPS field source inventory was done as part of a road sediment survey and consists of road sediment delivery points. This is a second order stream based on the 1:24,000 USGS topographic map, but it receives very little flow contribution from a small side drainage and another tributary. In early July 2003, the monitoring station located near the mouth was dry. This is probably related to losses to groundwater associated with the granitic geology. No surface diversions of flow for irrigation or other purposes were noted during the field surveys.

C.3.1.11 Warm Springs Creek (from the Middle Fork to the mouth) MT411006_110

Stream segment MT411006_110 is approximately three miles in length and is impacted by sediment and metals. Road maintenance and runoff, and tributary streams contribute sediment to the stream. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates. The Middle Fork and North Fork of Warm Springs, and possibly natural hot springs contribute metals. Diffuse sediment sources associated with rural home sites and irrigated hay fields may also affect the stream. Private property lines the entire length of the stream segment. The primary land uses are rural housing and agriculture (hay production and pasture). The stream's floodplain has extensive rural home development, but most of the stream course is allowed to meander naturally, with the exception of road crossings. Most of the stream conforms to a Rosgen C-type stream, with some sections of B. During the air photo

assessment, some minor road encroachment was noted and the lower portion of the stream was channelized. Riparian buffers were variable in width depending on location. In-stream sediment deposition was observed at the beginning of the segment. This is thought to result from a combination of factors, including the confluence of tributaries, a decrease in valley slope, and localized sediment sources associated with home construction activities.

The Tetra Tech/Land & Water field team performed a field investigation on a portion of Warm Springs Creek below the Woodland Park loop road in summer 2003. The field team gave the stream a rating of "functional-at risk", citing excessive sediment deposition and a limited riparian area as causes for concern. GPS source assessment attributes included road sediment delivery points, a road construction site, a problem culvert, an animal confinement area, and natural hot springs discharges (close to the mouth). Below are selected field measurements recorded at one of the natural hot springs.

SITE ID	pH	Temperature (°C)	Dissolved O_2 (mg/L)	Conductance (µS/cm)
WS-5	6.87	52.3	< 1.0	1008

C.3.1.12 Clancy Creek (headwaters to the mouth) MT41I006_120

Stream segment MT41I006_100 is approximately 11 miles in length and is impacted by sediment, metals, and habitat and channel alterations. Road maintenance and runoff, and bare stream banks contribute sediment. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates. Historic hard rock mining operations in the upper watershed contribute metals. Historic placer mining has altered stream morphology and possibly hydrology. Diffuse sediment sources associated with grazing, rural housing, and hay cultivation may also affect the stream. Private property lines the majority of the stream and the BLM is the only other landowner.

From the beginning of the 303(d)-listed segment to the confluence with Quartz Creek, Rosgen stream type transforms from an A to altered reaches of C and B. The primary land use is grazing, with a deferred rotation grazing system on BLM lands. In the headwaters area, there are over ten historic hard rock mines, including two high priority sites. Cattle graze along the stream and have trampled banks and reduced riparian vegetation. There is also evidence of beaver activity. The Clancy Creek road is a major sediment source above Quartz Creek, where gully and rill erosion was observed. The Tetra Tech/Land & Water field survey team investigated a portion of the headwaters segment. The team gave the stream a rating of "non-functional". GPS source assessment features within this stretch of the stream included road sediment delivery points, poorly managed grazing lands, and a mine waste rock dump.

From the confluence of Quartz Creek to the mouth, the stream alternates from a Rosgen C stream type, to a disturbed channel with characteristics of B, C, F, and G channels. The primary land uses are hay fields and pasture, and rural housing. Over half of the stream below the Quartz Creek confluence has been incised, widened, and straightened by historic placer mining. Of the 303(d)-listed segments in the Lake Helena planning unit, placer mine tailings are most extensive on Clancy Creek. Housing development gradually increases towards the town of Clancy. Riparian vegetation buffers are variable in width due to hay cultivation, placer tailings mounds, and development close to the stream. Clear-cut logging has occurred in adjacent uplands to the south of the stream. An old burn was visible on the surrounding hill slopes closer towards the mouth. The Tetra Tech/Land & Water field team performed a field investigation on a portion of this segment above Clancy during summer 2003. The field team assigned a rating of "non-functional" to the segment. GPS source assessment features on this stretch of the stream included road sediment delivery points, a problem culvert, animal confinement areas, and an irrigation diversion.

C.3.1.13 Lump Gulch (headwaters to the mouth) MT411006_130

Stream segment MT 411006_130 is approximately 14 miles in length and is impacted by sediment, metals, and habitat and channel alterations. Road maintenance and runoff, bare stream banks, and mine tailings contribute sediment. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates. Historic hard rock mining operations in the upper watershed contribute metals. Historic placer mining has altered stream morphology and possibly hydrology. Diffuse sediment sources associated with logging activities, grazing, rural housing, and hay cultivation may also affect the stream. This segment will be reviewed on the basis of ownership.

The headwaters portion of the stream flows on the HNF, but the majority of the land surrounding the creek is private property due to patented mining claims. Rosgen stream type goes from an A to altered A, B, and C reaches. The HNF portions of the watershed are managed for timber harvest and grazing. There is some dispersed rural housing along the creek on private property. In the headwaters area there are over ten historic hard rock mines, including four high priority sites in Frohner Basin. During the air photo assessment, the drainage was observed to be disrupted by historic dams at the Frohner Meadows Mine. Heavy logging was visible on the hill slopes to the south of the stream. The HNF field survey team investigated a portion of the headwaters segment. HNF gave the stream a rating of "functional-at risk", noting sediment deposition and upstream impacts. HNF GPS source assessment features documented along this stretch of the stream included road sediment delivery points, mine waste rock dumps, a mining dam, and channel incision.

From the HNF administrative boundary to the mouth, the stream alternates from a Rosgen B stream type to altered B and C reaches. The primary land uses are hay fields and pasture, and rural housing. Housing development gradually increases towards the mouth. Riparian vegetation buffers are variable in width due to distance from roads, development close to the stream, and hay cultivation. The HNF and Tetra Tech/Land & Water field teams investigated a portion of this segment below Buffalo Gulch. The stream was given a rating of "functional-at risk", again noting sediment deposition and upstream impacts. Below the forest boundary, stream access was restricted due to the prevalence of home sites along the floodplain. GPS source assessment features documented along this stretch of the stream consisted of road sediment delivery points. Intermittent logging, grazing activities, hay cultivation, and removal of riparian vegetation were also witnessed.

C.3.1.14 Jackson Creek (headwaters to the mouth) MT411006_190

Stream segment MT411006_190 is approximately 2.5 miles in length and is impacted by sediment. Fire disturbance and unpaved road runoff contribute sediment. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates.

The upper half of the stream segment flows through a section of the HNF Elkhorn Management Unit and the lower half flows through private property. This area of the Elkhorns is managed for big game habitat and optimal water quality. The upper portion of the watershed is restricts motorized vehicles yearlong. There is some dispersed housing near the creek on the private land. The stream goes from a Rosgen stream type Aa to Ba. The headwaters area has extremely rugged terrain with exposed rock outcrops and rockslides. In 1988, the whole drainage was burned over in the Warm Springs wildfire. During the air photo assessment, which was based on 1999 vintage, post-fire photos, most vegetation present in the watershed was restricted to riparian areas. There is a moderately high density of roads in the watershed, with minor road encroachment on the stream corridor.

The Tetra Tech/Land & Water field team performed a field investigation on a portion of this segment near the mouth in summer 2003. The field survey team gave the stream a rating of "proper functioning condition". Although excess sediment was observed in the stream, many pools and healthy, diverse riparian vegetation were observed. Due to access constraints, no source assessment features were documented with the GPS.

C.3.2 Tenmile Creek Drainage

C.3.2.1 Tenmile Creek (headwaters to Helena PWS intake above Rimini) MT41I006_141

Stream segment MT41I006_141 is approximately 6.5 miles in length and is impacted by sediment, metals, habitat and channel alterations, and flow alteration. Road maintenance and runoff, and bare stream banks contribute sediment. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates. Historic hard rock mining operations in the upper watershed contribute metals. Historic placer mining and current water diversions have altered stream morphology and hydrology.

The headwaters portion of the stream flows on the HNF, but the majority of the land surrounding the creek is private property due to patented mining claims. Rosgen stream type goes from an Aa to altered A and B reaches, with a few less confined sections (C and E). The HNF manages this area as part of the municipal watershed for the City of Helena. A small portion of the upper watershed is managed for timber harvest, while no resource development is to occur in the rest of the watershed. Dispersed rural housing occurs on private property. Housing development gradually increases towards the town of Rimini. Over twenty historic hard rock mines are present in the headwaters area, including five high priority sites. During the air photo assessment, major clear-cuts were visible on private lands in the headwaters area. Riparian buffer widths were variable due to moderate road encroachment (Rimini Road and secondary HNF roads), and from private land uses. Stream incisement and eroding stream banks were noticeable. Channelization of the stream to accommodate the Rimini Road was evidenced by a meander cutoff.

The HNF field survey team investigated two sites along the headwaters segment: two-thirds of a mile from the headwaters, and above the confluence with Banner Creek. At the upper site, the HNF gave the stream a rating of "proper functioning condition", and noted that the site could be a reference candidate. At the lower site, the HNF gave the stream a rating of "functional-at risk", observing sediment deposition and recovery from mining impacts (channel incisement, lack of riparian vegetation). HNF GPS source assessment features included placer tailings, historic mining dams, stream channelization, channel incisement, road crossings, and sediment delivery points.

C.3.2.2 Tenmile Creek (Helena PWS intake above Rimini to Helena WTP) MT41I006_142

Stream segment MT41I006_142 is approximately seven miles in length and is impacted by sediment, metals, habitat and channel alterations, and flow alteration. Road maintenance and runoff, upstream sources, and bare stream banks contribute sediment. Upstream and localized sources contribute metals contaminants. Channelization from roads and current water diversions has altered stream morphology and hydrology. Diffuse sediment and nutrient sources from subdivisions may also affect the stream. Dewatering along this segment has severely affected the flow regime.

About half of the stream segment flows on the HNF and half on private property. Most of the upland portion of the watershed is within the HNF. The HNF portions are managed primarily for timber harvest, wildlife habitat, and grazing. There are also some sections managed for the municipal watershed for the City of Helena, where timber harvest occurs, as well as areas of no resource development. The primary land uses on private property are rural housing and subdivisions. Housing development increases towards the end of the segment. During the aerial photo assessment, many meander cutoffs associated with the Rimini Road were observed along this segment of Tenmile Creek. In many reaches, the stream does not conform to a Rosgen stream type, but has sections of B, C and F channels. Again, stream incisement and eroding stream banks were visible. Lack of flow was evident, with water visible in only half of the

channel. Riparian belt width was limited due to major encroachment from the Rimini Road. Intermittent logging has occurred in hill slopes surrounding tributary streams.

The Tetra Tech/Land & Water field team performed a field investigation on a portion of this segment below the confluence with Bear Gulch. The field survey team gave the stream a rating of "functional-at risk", mostly on the basis of riparian vegetative and energy dissipating characteristics. GPS source assessment features were collected by the HNF and Tetra Tech/Land & Water teams. Documented sites include road sediment delivery points, loss of riparian vegetation, placer tailings, lack of flow, and suspected wastewater seepage from individual septic systems.

C.3.2.3 Tenmile Creek (from Helena WTP to mouth) MT41I006_143

Stream segment MT41I006_143 is approximately 16 miles in length and is impacted by sediment, habitat and channel alterations, metals, nutrients, and flow alteration. Road maintenance and runoff, road construction, upstream sources, tributary streams, and bare stream banks contribute sediment to the stream. Channelization associated with roads and agricultural operations have altered stream morphology. Upstream sources contribute metals contaminants. Irrigation diversions, grazing practices, and upstream sources contribute nutrients. Dewatering has affected the natural hydrology of the stream and the quality of aquatic habitat. Diffuse sediment and possibly nutrients sources from rural housing and subdivisions also affect the stream.

Private property lines the entire length of the stream segment. The primary land uses are hay fields and pasture, rural housing, and subdivisions. In many stretches, the stream does not conform to a Rosgen stream type, but has reaches of C and F channels. During the air photo assessment, about 16 percent of the segment was observed to be affected by channelization (mainly associated with Highway 12). Riparian buffer widths were variable depending on land uses and management practices. Exposed and eroding stream banks were visible. Once the stream enters the Helena Valley, the number of rural subdivisions potentially impacting the stream greatly increases. However, the beginning and end of this segment of Tenmile Creek are largely composed of ranch and agricultural lands.

The Tetra Tech/Land & Water field survey team investigated two portions of this segment: above Sevenmile and above Green Meadow Drive. The team gave ratings of "functional-at risk" to both stream segments. Healthy and diverse riparian vegetation was noted, as were bank alterations and excessive sediment. Chronic dewatering is an issue, as the stream was observed dry or almost dry at four of 11 locations where observations were made. Source assessment features included animal confinement lots, construction sites, road crossings, sediment delivery points, and areas where the stream channel was dry. At one point the stream flows through a golf course where channel straightening has occurred, and natural riparian vegetation has been replaced with a manicured lawn to the stream's edge.

C.3.2.4 Skelly Gulch (tributary of Greenhorn Creek) MT41I006_220

Stream segment MT41I006_220 is approximately seven miles in length and is impacted by sediment, metals, and habitat and channel alterations. Road maintenance and runoff, and road construction contribute sediment to the stream. Historic hard rock mines in the upper watershed contribute metals. Historic placer mining has altered stream morphology and possibly hydrology. Diffuse sediment sources from grazing, rural housing, and historic hard rock mining may also affect the stream.

The headwaters of this stream flow on the HNF, where the stream is mainly a Rosgen type A channel. The HNF manages the area for timber harvest and grazing. During the air photo assessment, clear-cuts were observed in the headwaters relatively close to the stream course. Riparian buffer areas were

extensive, except where limited by minor road encroachment. The stream is intermittent from its headwaters until the aspect change from east-west to north-south. The HNF portion of the stream was assessed for sources by the HNF. Their GPS inventory documented road sediment delivery points, channel incision and channelization from placer mining, bank trampling and loss of riparian vegetation due to livestock grazing, and one mine waste rock dump within the stream bank full width.

Private property lines the majority of the stream from the HNF boundary to Skelly Gulch's confluence with Sevenmile Creek. Intermittent parcels of BLM land are also present. The stream is mainly a Rosgen stream type B with a few sections of C. During the air photo assessment, variable riparian buffer widths and moderate road encroachment from the Skelly Gulch Road were observed. The primary land use is rural housing. Due to access constraints, limited source assessment features were recorded along this segment. GPS sites included road sediment delivery points, a problem culvert, and beaver ponds. Areas of high sedimentation were documented near the mouth. The Tetra Tech/Land & Water field survey team investigated a portion of this segment below the confluence with Jeff Davis Gulch. The team assigned the stream a rating of "proper functioning condition". Healthy and diverse vegetation were noted, as were good fish habitat components.

C.3.2.5 Sevenmile Creek (headwaters to mouth) MT41I006_160

Stream segment MT41I006_020 is approximately eight miles in length and is impacted by sediment, habitat and channel alterations, metals, nutrients, and flow alteration. Road maintenance and runoff, upstream sources, and bare stream banks contribute sediment to the stream. Channelization from roads, railways, and agricultural operations has altered stream morphology and possibly hydrology. Upstream sources contribute metals contaminants. Irrigation return flows, grazing practices, and upstream sources contribute nutrients. Irrigation water withdrawals affect aquatic habitat and stream hydrology. Diffuse sediment and possibly nutrients sources from rural housing may also affect the stream.

Private property lines the majority of the stream segment. Intermittent parcels of BLM land are also present. The primary land uses are as a transportation corridor, hay fields and pasture, and rural housing. On BLM lands near the stream, the railroad has the right of way. In many stretches, the stream does not conform to a Rosgen stream type, but has some stretches of C, B, and G channel types. During the air photo assessment, the segment from the headwaters to the Austin Road crossing was observed to be affected by channelization from the railway. According to the BLM, the railroad managers have "built fire breaks that have caused increased sedimentation in the creek". Stream incisement and eroding stream banks were visible about one and one-quarter miles downstream of the Austin Road crossing. It appeared that the stream had down dropped about three channel widths, with trees and brush growing in this incised area. This could be associated with a large irrigation diversion, noticeable just below the beginning of the incision. After the diversion, the stream did not fill the entire channel. Riparian buffer widths were variable depending on land management practices. Nearer to the stream's mouth, there is a noticeable increase in subdivision developments but none are immediately proximal to the stream.

Due to access constraints, limited source assessment features were recorded along this segment. GPS features that were documented include road sediment delivery points, an animal confinement area, an irrigation diversion, and suspected wastewater seepage from Fort Harrison's defunct sewage treatment facility. Excessive sediment was noted at the Birdseye Road crossing and near the mouth, with sand and silt being the dominant substrate materials. The Tetra Tech/Land & Water field survey team investigated a portion of this segment above the mouth. The team gave the stream a rating of "functional-at risk". While healthy riparian vegetation was observed, stream dewatering appears to be a significant problem.

C.3.3 Silver Creek Drainage

C.3.3.1 Jennie's Fork (headwaters to mouth) MT41I006_210

Stream segment MT41I006_210 is approximately 1.5 miles in length and is impacted by sediment, habitat and channel alterations, and metals. Road maintenance and runoff, and a large unpaved parking lot contribute sediment. The granitic geology of the watershed exacerbates sediment delivery owing to rapid erosion rates. Historic mining operations and ski area development have altered channel morphology and possibly hydrology. Historic hard rock mining operations in the watershed contribute metals.

Most of the stream flows on private property, with some BLM ownership in the headwaters. The primary land use is recreation associated with the Great Divide ski area, with the historic gold mining town of Marysville located near its mouth. The stream goes from a Rosgen stream type Aa to B. During the air photo assessment, variable width riparian buffers and major road encroachment were observed. There is an extremely high density of roads in the watershed, especially in the vicinity of the ski resort.

During the source assessment, it was learned that Jennie's Fork point of origin is a mine shaft on Mt. Belmont. The state has done significant reclamation work at this location and mining was active at this particular site until the late 1990s. GPS features included road sediment delivery sites, problem culverts, stream channelization from roads, and channel incision. It appears that many of the culverts along the stream are undersized to handle runoff events. Below the ski area parking lot, there is evidence of at least three channels that carry flow during spring runoff. Cattle and horses were observed grazing below the parking lot, and have trampled the stream banks and destroyed riparian vegetation. The Tetra Tech/Land & Water field survey team investigated a portion of this segment below the Great Divide ski area in summer 2003. The field survey team gave the stream a rating of "functional-at risk", mostly on the basis of poor riparian vegetation and energy dissipating characteristics.

C.3.3.2 Silver Creek (headwaters to mouth) MT41I006_150

Stream segment MT41I006_100 is approximately 21 miles in length and is impacted by habitat and channel alterations, sediment, metals, nutrients, and flow alteration. Historic placer mining and irrigation diversions and canals have altered stream morphology and hydrology. Road maintenance and runoff, road construction, tributary streams, in-channel sources, and diffuse non-point sources associated with rural housing and grazing contribute sediment to the stream. Historic hard rock mining operations in the upper watershed contribute metals. Irrigation diversions and diffuse source areas associated with grazing, rural housing, and subdivisions contribute nutrients. Except for small sections of BLM land in the upper portion of the segment, private property lines the entire stream.

From the beginning of the 303(d)-listed segment to the first valley opening above Silver City, Rosgen stream type goes changes between altered B and altered C reaches. Land use near the stream corridor is limited due to the remnants of historic mines and mills. Grazing occurs on upslope BLM lands, and an unpaved road above the left bank of the stream travels to the historic gold mining town of Marysville and on to the Great Divide Ski Area. During the air photo assessment, over half of this section of the stream segment was observed to be incised, widened, and straightened by historic placer mining. GPS source assessment features on this stretch of the stream included road sediment delivery points, beaver pond complexes, placer mine tailings piles, and a problem culvert.

From the first valley opening above Silver City to Green Meadow Drive, the stream alternates from a Rosgen C stream type to a disturbed channel with characteristics of C and F channels. During the air photo assessment there was a noticeable increase in stream sinuosity through this reach, but some sections

appear to be channelized for irrigation purposes. The primary land uses are hay fields and pasture, and rural housing. Housing development gradually increases towards Green Meadow Drive. Riparian vegetative buffers were variable depending on landowner and land uses. GPS source assessment features on this stretch of the stream included road sediment delivery points, riprap, and a dry streambed at Green Meadow Drive.

After crossing Green Meadow Drive, the entire stream course is channelized in irrigation ditches and canals. Some stream flow is replenished from irrigation returns and groundwater drains. The primary land uses are hay fields and pasture, rural housing, and subdivisions. A channel resembling a stream course doesn't appear again until just before entering Lake Helena. Due to access limitations, no source assessment features were documented with the GPS along this portion of the stream.

C.3.4 Lake Helena

C.3.4.1 Lake Helena MT41I007_010

Lake Helena (MT41I007_010) is approximately 2,100 acres in size and is the ultimate receiving water body for streams draining the 620 square mile Lake Helena watershed. The Lake Helena portion of the Helena Valley originally consisted of a wetland complex that ranged in size from 3,600 to 7,800 acres (Wetlands Community Partnership, 2001). In 1907, Hauser Dam and Reservoir were constructed on the Missouri River north of Helena. Water backing up behind the dam inundated the lower reaches of Pickly Pear Creek and the surrounding wetlands thereby creating Lake Helena. In 1945, an earthen causeway and control structures were installed to allow independent regulation of water levels in Hauser Reservoir and Lake Helena (Shields, et. al., 1995). The Lake Helena Causeway now separates Lake Helena from the so called Causeway Arm of Hauser Reservoir. Each of these two reservoir segments is listed as a separate segment on the Montana 303(d) List.

The primary pollutant sources identified as affecting Lake Helena during the pollution source assessment were tributary streams, a variety of non-point pollution sources, and natural geologic factors. Tributary streams, diffuse non-point sources, and natural sources were documented as contributing sediment, nutrients, and metals to Lake Helena. These observations and conclusions were based on literature reviews, interpretation of available aerial photographs, and analysis of a variety of chemical, physical, and biological samples.

The lowest elevations in the Helena Valley are occupied by Lake Helena, which lies over Quaternary alluvial valley bottom sediment deposits. Lake Helena is a very shallow water body with an average depth of 5.2 feet. The surface area is approximately 3.2 square miles, or 2,072 acres. The limnology of the lake is strongly influenced by a large watershed area to lake area. The water surface elevation of Lake Helena is partly controlled by Hauser Dam on the Missouri River and a control structure at the Lake Helena Causeway. The water level in Hauser Lake upstream from Hauser Dam is managed for power generation, flood control and recreational uses. Missouri River flow into and out of Hauser Reservoir is coordinated with the operation of upstream and downstream hydroelectric dams (Canyon Ferry Dam and Holter Dam, respectively). Lake Helena does not continuously discharge water to Hauser Reservoir. On occasion, depending on the respective water levels of the two reservoirs, flow direction may reverse with Hauser Reservoir discharging water to Lake Helena (Shields et. al., 1995).

Hydrologic inputs to Lake Helena include the major tributary streams (Prickly Pear Creek, Tenmile Creek and to a lesser extent, Silver Creek), ground water discharge, tile drainage associated with the Helena Valley Irrigation District (HVID), treated wastewater discharges from the cities of Helena and East Helena (discharged to Prickly Pear Creek), and the Missouri River via direct or indirect discharges from the Helena Valley Irrigation Canal and from occasional backflows from Hauser Reservoir to Lake Helena (Kendy et al., 1998). In the summer, the lower reaches of both Prickly Pear and Tenmile creeks are severely dewatered due to irrigation withdrawals and their direct discharges to Lake Helena are negligible. Most of Silver Creek's small volume of flow never reaches the Helena Valley due to channel losses to ground water and irrigation withdrawals. Silver Creek becomes a channelized ditch in its lower reaches and groundwater tile drainage discharging from the west and north portions of the Helena Valley comprise most or all of its flow. During the summer season, when a large volume of Missouri River water is imported into the Helena Valley to irrigate crops, direct discharges from the main Helena Valley Irrigation Canal and an extensive series of lateral canals provide most of the inflow to Lake Helena. An additional but unquantified volume of Missouri River water enters Lake Helena via ground water discharges from irrigated fields within the Helena Valley Irrigation District. During the 2003 irrigation

season (April 1 to September 30), an average daily flow of 231 cfs was discharged from the Missouri River Helena Valley Regulating Reservoir through the HVID canal system (Personal communication, Jim Foster, October 2004). Most of this water can be assumed to eventually reach Lake Helena, minus evapotranspiration losses from irrigated fields. In contrast, average daily flows for Prickly Pear Creek (near Clancy), McClellan Creek (near the mouth), and Tenmile Creek (near the mouth) for the April 1 to September 30 timeframe total about 143 cfs (USGS 2004).

Lake Helena is surrounded by private lands, with the exception of a small public waterfowl preserve operated by Montana Fish, Wildlife and Parks that is located along the northwestern shore. Pacific Power and Light (PP&L) has a 603 acre easement along the west and south shoreline areas of the lake to accommodate fluctuating water levels that result from the operations of Hauser Dam. Private parcels along the western and southern edges of the lake consist of ranches and large residential lots with livestock pasture and hay fields that extend to the lake's edge. On the north and east shores of the lake, recent subdivision development has resulted in the construction of many homes on one acre (mostly near the causeway) or twenty acre lots. Interestingly, when the Lewis and Clark County cadastral land ownership GIS layer is overlain on a current aerial photo of the area, many of the subdivided lots on the north shore of Lake Helena have half of their parcels inundated by water.

Waterborne contaminants originating within many of the 303(d) listed streams drainages are ultimately transported to Lake Helena. Diffuse pollution sources associated with rural housing, agricultural practices, and natural sources also affect the lake. Although the area was once a substantial wetland, the majority of riparian vegetation is now restricted to the portion of shoreline where Prickly Pear Creek and the Silver Creek Ditch enter the lake. This corresponds to the area protected by the PP&L easement. The Missouri River irrigation water interbasin transfer may contribute to an increase in arsenic loading to Lake Helena, while surplus irrigation water discharges, return flows, and tile drainage may be sources of nutrient loading. During a 2003 pollution source assessment, open drains discharging tile drainage and excess irrigation water to Lake Helena were observed to contain high densities of aquatic plants and large numbers of dead carp. The majority of the Lake Helena watershed drains an area with granitic geology and a naturally high capacity for erosion and production of sediment. Aerial photographs reviewed as part of the 2003 source assessment showed a deltaic formation in Lake Helena where Prickly Pear Creek discharges to it. Field monitoring activities documented a shifting stream substrate composed of granite sands in much of lower Prickly Pear Creek. Other natural sources such as wind events contribute to shoreline erosion, especially along the east shoreline near the Lake Helena Causeway. Historical aerial deposition of metals and other contaminants from the ASARCO East Helena lead smelter is another potential but unquantified source of impairment in Lake Helena.

C.4.0 CONCLUSIONS

Pollution sources documented in the Lake Helena TPA resulted from historic and current anthropogenic activities, as well as natural factors. Historic pollution source-generating activities included hard rock and placer mining, logging, and various categories of roads. Present-day sources were generally associated with agricultural practices and urban and suburban development. Natural sources of pollution identified in the Lake Helena watershed included highly erosive granitic geology that encompasses much of the area, the residual effects of forest fire and historical floods, and possibly hot springs (thermal and/or chemical sources).

Historical placer and lode mining have left lasting imprints on the landscape. Placer and lode mine and mill tailings piles, acidic metals-laden adit discharges, channelized and incised stream courses, and altered hydrology are common examples of the detrimental effects of the mining legacy in the Lake Helena watershed (Figure 2). While the state and federal mine reclamation programs have made significant progress, the list of problematic sites is long and reclamation is costly. Additionally, candidate sites are

prioritized on the basis of human health threats. Water quality, especially sub-lethal impairment of aquatic life, generally receives less attention.

Most effects of logging and road building in the forested areas of the watershed appeared to be less significant than in the recent past. Federal and state laws pertaining to logging and road building practices have evolved to become more protective of water quality and riparian areas. At the same time, timber harvests on most state and federal lands have declined from former levels. Despite this trend, problems remain and these should be addressed through application of best management practices.

As for road management activities on the Helena National Forest, forest staffs are currently working to revise the forest travel management plan. According to scoping information provided by the forest, "the purpose for initiating this proposal is to have a network of open roads and trails that addresses the need for a variety of uses while meeting goals, objectives, and standards for the multiple resources present within the project areas" (USDA 2004a). Watershed, water quality and fisheries are resources that will be addressed within the context of the travel plan.

Current agricultural land management activities on private and public lands in the Lake Helena TPA are significant sources of water quality impairment. In many instances poor grazing practices were observed on HNF and private lands. These activities have led to degraded riparian areas, unstable stream banks, and increased delivery rates of sediment, nutrients, and pathogens to listed streams. A few concentrated livestock feeding operations were observed on private lands within close proximity to listed stream segments. Many cultivated areas extended virtually to the stream banks, resulting in little or no riparian buffer area.

Agricultural, municipal and industrial water withdrawals and inter-basin water transfers were witnessed as depleting many of the listed streams normal flows and their abilities to transport normal sediment loads and to dilute contaminants. In some segments, water diversions left streams completely dewatered for much of the summer season. Irrigation return flows potentially contaminated with nutrients, sediment and pathogens were also observed.

Many traditional agricultural areas in the Lake Helena watershed continue to be rapidly transformed into 'ranchettes' and subdivisions. Individual residences and housing developments are becoming common or abundant in the mountain front areas and especially in the Helena Valley. These home sites and associated road networks have increased the amount of impervious surface area in the watershed, which can affect the timing of runoff and speed the delivery of pollutants to streams. In turn, impervious areas are unavailable for recharge to the water table. Roads and road building have led to channelization, alterations of stream banks, degradation of riparian areas, and increased surface runoff (Figure 3). Moreover, the majority of new homes are serviced by individual wells and septic systems, which can alter stream flows and contribute nutrients to watersheds.

Natural sources of pollution in the Lake Helena TPA can exacerbate problems stemming from anthropogenic sources. This is particularly true in the case of the highly erosive granitic geology that encompasses much of the watershed. The Boulder Batholith (TKb) and associated rock formations are composed primarily of quartz monzonite (Figure 4). This rock formation produces coarse sands that are easily transported during runoff events. Rill and gully formations were observed in disturbed TKb hill slope areas near 303(d)-listed streams. Many of the listed streams found in the TKb geology were also witnessed to contain heavy amounts of deposited sand. Even least-impaired reference streams located within this geology experienced surplus sand deposition.

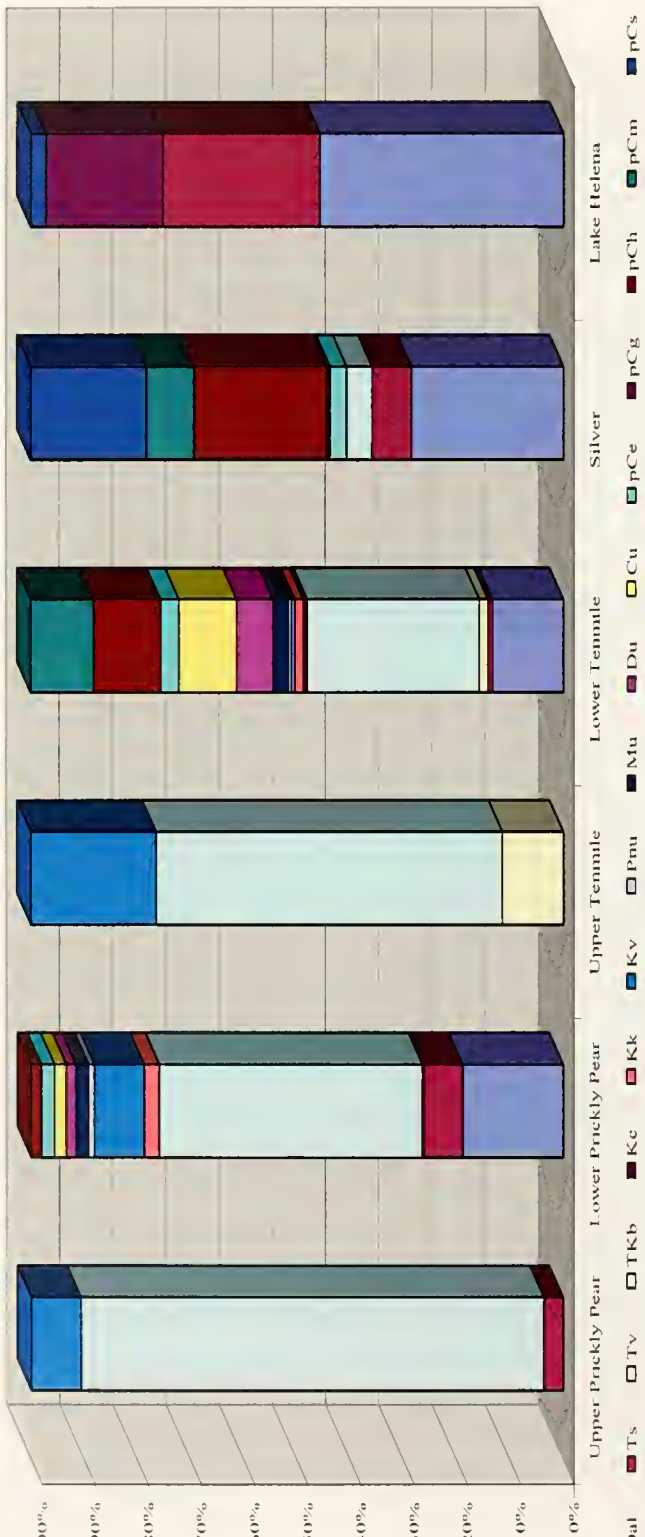
Other natural sources observed in the Lake Helena TPA included the effects of the Warm Springs Creek wild fire of 1988. Of the listed stream segments, the Jackson Creek drainage was most affected by the

Warm Springs fire, with its entire watershed area being burned over. Loss of vegetation coupled with steep granitic hill slopes led to an introduction of excess sediment into the drainage system. Another possible natural source of impairment was associated with hot springs discharging to Warm Springs Creek. The hot springs were located near the mouth, and there was even a medical facility that utilizes a developed thermal spring at Alhambra. Other developed hot springs were noted at the Broadwater Athletic Club along lower Tenmile Creek, and just downstream at a local residence (outdoor pool). Thermal springs may contribute to temperature impairments for coldwater aquatic life and may contain metals and other chemical contaminants.

The presence of constructed dams on lower Prickly Pear Creek at the ASARCO smelter facility and on the Missouri River at Hauser Dam created other types of problems. The ASARCO Dam just above East Helena on Prickly Pear segment MT41I006_040 and associated industrial cooling water ponds were thought to impair fish passage, decrease stream gradient, increase the level of channel embeddedness, and increase water temperatures during the 2003 field visits. Hauser Dam on the Missouri River is responsible for the creation of Lake Helena and its operation controls water levels and hydraulic residence times in the lake. "Flow between Hauser Lake and Lake Helena depends on the level of Hauser Lake, which is controlled for power generation, relative to the level of Lake Helena. Although the net flow direction is from Lake Helena to Hauser Lake, flow temporarily reverses direction almost daily" (Kendy et. al 1998, p.10). Therefore, in addition to receiving waters from all the streams draining the Lake Helena watershed, Lake Helena often receives inflows from the greater Missouri River/Hauser Reservoir system.

Figure C-2. State inventoried mines by subwatershed in the Lake Helena TMDL Planning Area.
Source: Montana State Library Natural Resource Information System, http://nris.state.mt.us/gis/datalist.html, GIS Layers: Mines (US Bureau of Mines, 1992) and High Priority Abandoned Hardrock Mine Sites of Montana

Figure C-3. Kilometers of Roads by Subwatershed in the Lake Helena TMDL Planning Area
Source: Montana State Library Natural Resource Information System, http://nris.state.mt.us/gis/datalist.html, GIS Layer: Roads from 2000 US Census Bureau TIGER Files



Symbol	Formation	Primary Lithology	Secondary Lithology
Qal	Alluvium	silt	sand
Ts	Tertiary sedimentary rocks, undifferentiated	gravel	sand
Tv	Tertiary volcanic rocks	latite	quartz latite
TKb	Boulder batholith and broadly related rocks	quartz monzonite	diorite
Kc	Colorado shale	shale	siltstone
Kk	Kootenia formation and associated rocks	conglomerate	sandstone
Kv	Cretaceous volcanic rocks	intermediate flows and pyroclastic rocks	minor interbedded sedimentary rocks
Pnu	Pennsylvanian, undifferentiated	quartzite	limestone
Mu	Mississippian, undifferentiated	sandstone	shale
Du	Devonian, undifferentiated	carbonaceous shale	calcareous shale
Cu	Cambrian, undifferentiated	shale	limestone
pCe	Belt Series - Empire shale	shale	some red beds
pCg	Belt Series - Greyson shale	argillaceous shale	sandy shale
pCh	Belt Series - Helena limestone	limestone	argillaceous limestone
pCm	Belt Series - Missoula group	argillite	sandy or quartzitic argillite
pCs	Belt Series - Spokane shale	shale	locally quartzite

Figure C-4. Geology by major subwatershed in the Lake Helena TMDL Planning Area.
Source: Montana State Library Natural Resource Information System, http://nris.state.mt.us/gis/datalist.html, GIS Layer: 1:500,000 scale MBMG Geology

C.4.1 Patterns of Impairment

The following descriptions of spatial patterns of pollution sources in the Lake Helena TPA are broad generalizations meant to reflect issues of concern associated with common geographic characteristics. These characteristics include topography, land ownership, and geology.

Topographically, the Lake Helena TPA can be broken into three regions: mountain, mountain front, and valley areas (Figure 5). In mountainous areas, prevalent pollution sources affecting the listed stream segments were associated with unpaved roads, road placement, and abandoned mines. Usually, increased sediment was generated from unpaved roads and delivered to the listed streams. Road development adjacent to listed streams generally resulted in stream channelization and the loss of riparian buffer areas. Abandoned hard rock mines were common sources of acid mine drainage and contaminated sediments (mine and mill tailings, waste rock). Some mountain-area stream channels were incised, widened, channelized, or dammed by former placer and hard rock mining and milling activity.

Impairment sources affecting the mountain front and valley stream segments were more numerous and pronounced than those observed in the mountainous areas. In the valley areas, there are more lands available for development, and pollution sources tend to be cumulative and/or more complex. Paved and unpaved roads, stream channelization, stream bank alterations, hydromodification, floodplain development, and loss of riparian vegetation are common sources of concern for the 303(d)-listed segments within the mountain front and valley areas of the Lake Helena TPA. Some of the mechanisms of effect by which these sources contribute to water quality impairment are described below:

- Impermeable road surfaces can cause increased runoff to streams, which in turn can introduce pollutants. Road maintenance, such as sanding, salting, and grading, adds to the pollution sources available for runoff. Road construction adjacent to listed streams typically results in loss of riparian buffer areas, stream channelization, and/or bank alterations including riprap, dikes and bridges.

- Stream channelization changes channel form and can have negative consequences to fish habitat components (pools, riffles, and undercut banks). During high flow events, channelized streams are unable to effectively dissipate energy, which can result in destabilization of stream banks. A common response to destabilized stream banks is to riprap or armor stream eroding areas. Riprap may stabilize a bank at a particular spot, but usually sends increased stream energy downstream where perhaps even worse damage may occur. Riprap may also prevent a stream from accessing its floodplain, which is a natural mechanism of energy dissipation during high flow events and serves to replenish soil moisture essential to riparian vegetation.

- Hydromodification resulting from water diversions, dams, channel incisement, large scale placer or hydraulic mining, and other alterations of a watershed hydrology can affect sediment transport, dilution of contaminants, water temperatures, fish habitat, and riparian vegetation communities. Although irrigation return flows add water back to stream systems, often the water quality is poor due to the addition of contaminants such as sediment, nutrients, heat, and possibly pesticides and herbicides.

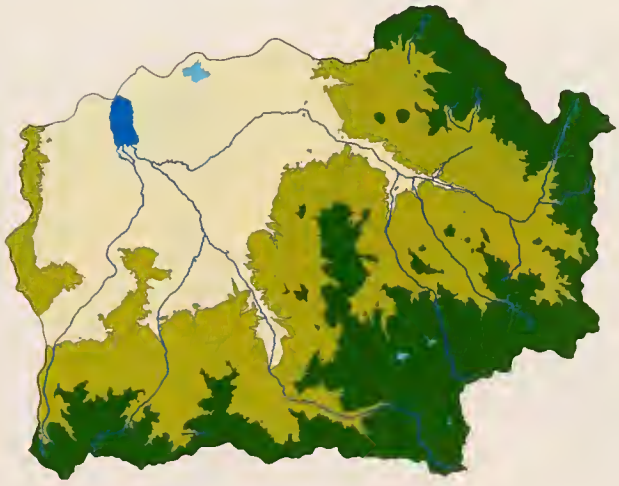
- Development activities within floodplains, besides a potential safety risk, can have negative consequences for streams. Residential development in the floodplain can lead to increased delivery of pollutants to streams. Residential runoff can be contaminated with sediment, lawn fertilizers, and household chemicals. Septic systems can be sources of contamination to streams if flood waters intercept a septic drain field, or if the system is improperly designed and

maintained. Property owners may operate wells (residential, industrial, municipal, and agricultural) in or near the floodplain. The wells may be hydraulically connected to surface water, and may influence stream flows or ground water discharges to streams. Well pumping can also cause contaminated surface water to enter the ground water. In addition, property owners may choose to remove riparian vegetation for landscaping purposes, which can lead to stream bank destabilization and associated problems.

- Loss of riparian vegetation can result from livestock browsing and bank trampling, road construction near the streams, contaminated soils that prevent vegetative growth, and removal for agricultural or aesthetic purposes. Riparian vegetation plays an important role in the maintenance of stream banks, water quality, stream flows, and fish habitat. During bank overflow events, the roughness of riparian vegetation serves to dissipate stream energy, and the roots of woody species help stabilize the bank. During runoff events, riparian vegetation can act as a filter by trapping and absorbing contaminants before they reach the stream. Riparian vegetation also provides shade, reduces solar inputs and maintains cool water temperatures, and provides cover for fish and other aquatic organisms. Stream channel incisement, which can stem from riparian degradation, may alter alluvial aquifers and stream flows.

The impairment sources and mechanisms of effect listed above affect both public and private lands within the Lake Helena watershed (Figure 6). The Helena National Forest and Bureau of Land Management are the largest public land management agencies in the Lake Helena TPA, respectively. The most common pollution sources identified on public lands were, in order of significance, unpaved road runoff, abandoned mines (including acid mine drainage, mine waste, and channel alterations), and riparian grazing impacts. The most frequently observed sources affecting privately owned portions of the watershed were, in order of significance, hydromodification (irrigation diversions/water transfers/return flows), loss of riparian vegetation, road runoff, stream channelization, riparian grazing impacts, and active and abandoned mines (including acid mine drainage, mine waste, and channel alterations).

Geological influences in the Lake Helena TPA are significant regardless of land ownership. Geology in the area is diverse, with formations ranging in age from the recent Holocene to the Precambrian (over 500 million years ago). However, the Boulder Batholith formation accounts for almost half of all the rock types present in the Lake Helena TPA (Figures 4 and 7). The granitic geology of the Boulder Batholith (TKb) and associated rock formations appear to create a pattern of excessive coarse sediment deposition. TKb is generally found in the sub-watersheds of Prickly Pear Creek, upper Tenmile Creek, and Jennies Fork. In addition to the highly erosive nature of these rock formations, the geology is associated with the presence of hard rock mines. During the formation of these intrusive igneous rocks many minerals were produced, which later led to mining development. In general, the listed streams found in this geology have high sediment loads, especially bed load. Furthermore, many of the 303(d)-listed stream segments within the TKb have been affected by metals, acid, sediment, and channel and bank alterations resulting from mining.



Topographic Region	Elevation (ft)
Mountain	5,500 to 9,350
Mountain Front	4,400 to 5,499
Valley	3,600 to 4,399

Figure C-5. Topographic regions of the Lake Helena TPA.
Source: Helena National Forest, GIS Layer: 2002, 30 Meter Digital Elevation Model of the HNF and surrounding lands (derived from the USGS National Elevation Dataset)

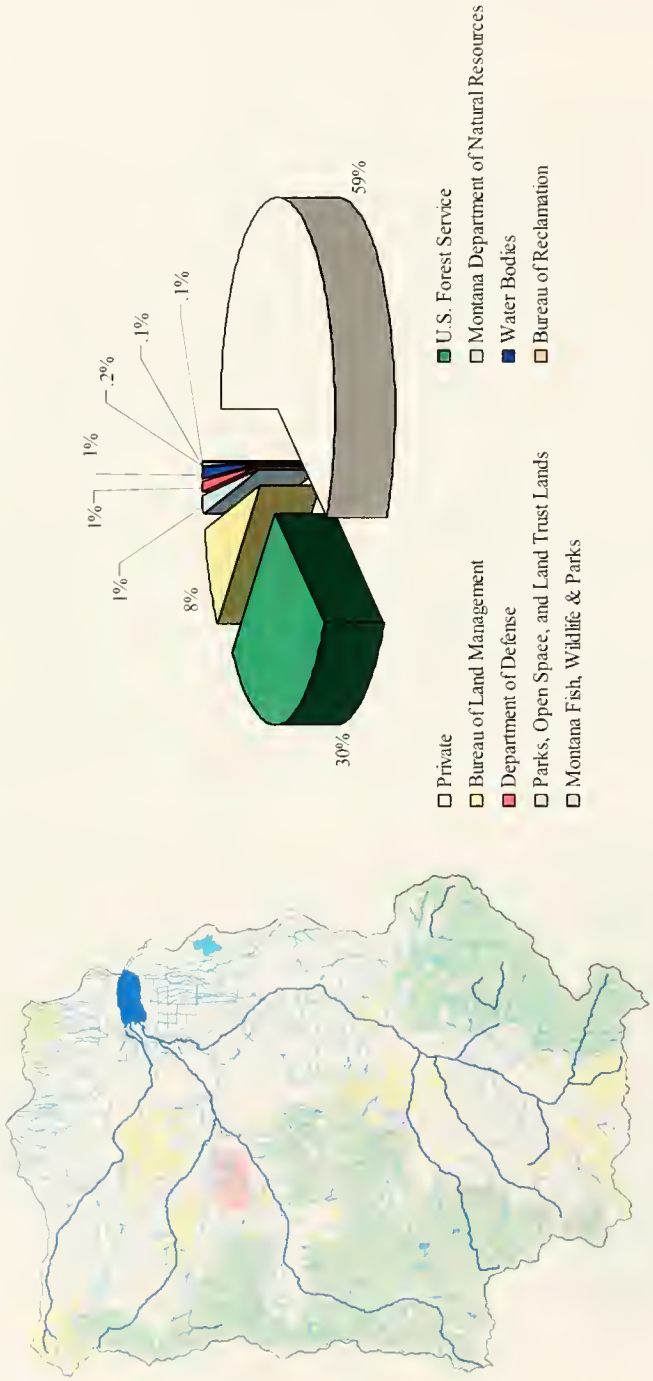


Figure C-6. Land ownership in the Lake Helena TPA.
Source: Bureau of Land Management, http://www.mt.blm.gov/gis/data/newdatapage.htm, GIS Layer: Surface Management

C.4.2 Potential Future Sources of Impairment

Foreseeable future impacts encompass a range of issues mostly related to suburban development. The valley stream segments of lower Tenmile, lower Prickly Pear, lower Silver and Sevenmile creeks, the Lake Helena area, and the mountain front stream segments of upper Prickly Pear, upper Tenmile, Spring, Corbin, Warm Springs, and Clancy creeks, and Lump and Skelly Gulches are likely to see continuing increases in residential home site development if current trends continue. Lewis and Clark and Jefferson Counties have seen average population growth rates of 20 and 25 percent, respectively, since 1980 (MT DOC 2003). From 1900 to 2000, Lewis and Clark County has seen a 191 percent overall increase in population, while Jefferson County has seen an 89 percent increase (MT DOC 2003).

According to the recently adopted Lewis and Clark County Growth Policy, "the Helena Valley is the primary population center and economic hub for Lewis and Clark County, and northern Jefferson and Broadwater Counties. The Valley continues to encompass the largest percentage of County population and growth. The majority of the growth is occurring in unincorporated areas within the Valley" (Lewis and Clark County 2004a, Executive Summary, p. 3). A similar pattern was noted in the growth policy for Jefferson County, which encompasses the southern third of the Lake Helena TPA. "[The growth] is most apparent in the northern section of the county where the communities of Clancy, Montana City, and Jefferson City have shown the most dramatic increase in population and subsequent residential subdivision" (Jefferson County 2003, p. 4).

Many of these new homes are serviced by individual wells and on-site septic systems (Figure 8). Possible reduction in the amount of ground water discharge to streams, and an increase in nutrient loading from septic leachate are potential negative impacts to surface water quality. New roads must be constructed to service unincorporated residential development. Channelization of streams due to construction of roadbeds, culverts, and bridges disrupts a stream's natural system of energy dissipation and can lead to unpredictable flooding and changes in channel form. Increases in impervious surfaces facilitate storm water runoff and can introduce pollutants where inadequate riparian buffers exist to provide filtration. Natural riparian areas may also suffer where stream front development occurs, especially where livestock are present on small parcels.

Although the City of Helena has plans to annex outlying portions of the area and to provide public water and sewer services, the capacity of the current systems have limitations. Currently, the city has plans to bring most areas within a 1-mile radius of the city limits onto municipal water and sewer supplies (Figure 9). However, this excludes many portions of the Helena Valley, including densely subdivided lands and private agricultural areas that are prime targets for future residential development. Both Lewis and Clark and Jefferson counties hope to maintain "the rural character" of their counties. Both counties' growth policies plan to encourage future development in areas that have already been developed, and where community water and sewer systems are already in place. However, encouragement can only go so far and without adequate incentives or more stringent regulations, water quality and riparian integrity of streams in the Lake Helena watershed are likely to continue to be impacted by rapid suburban development.

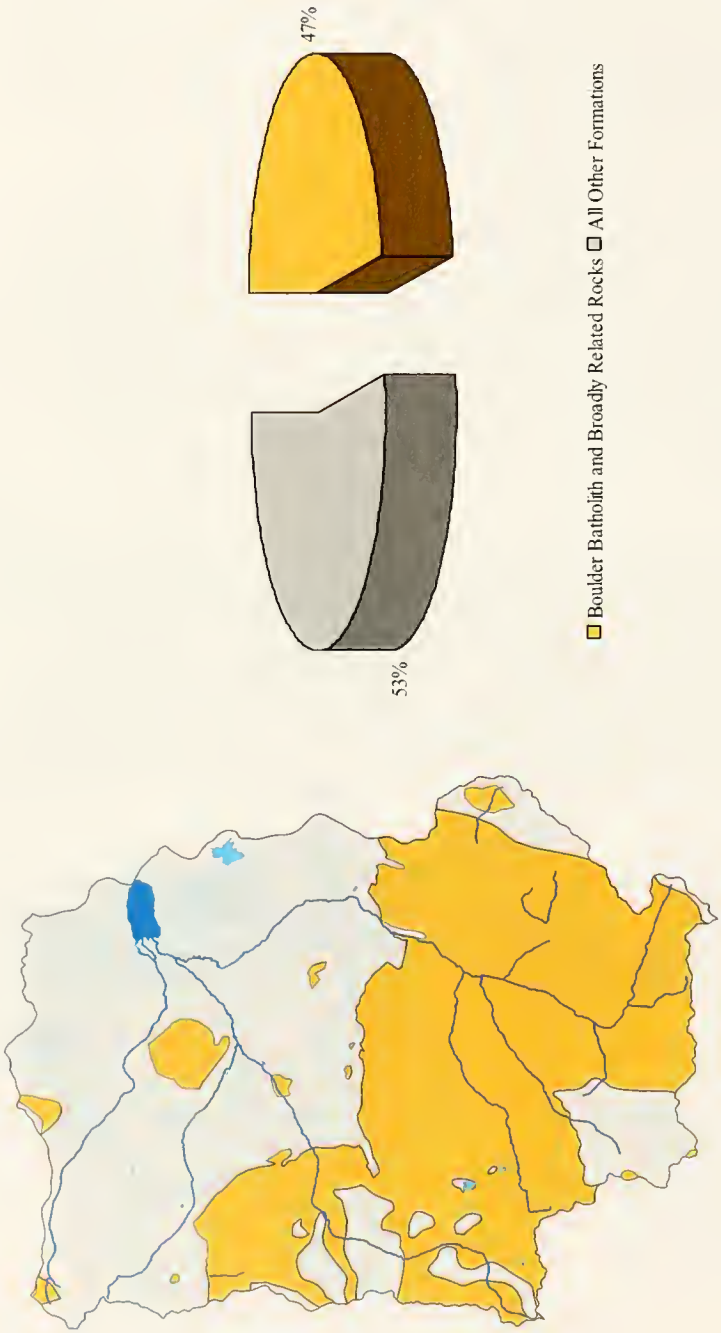
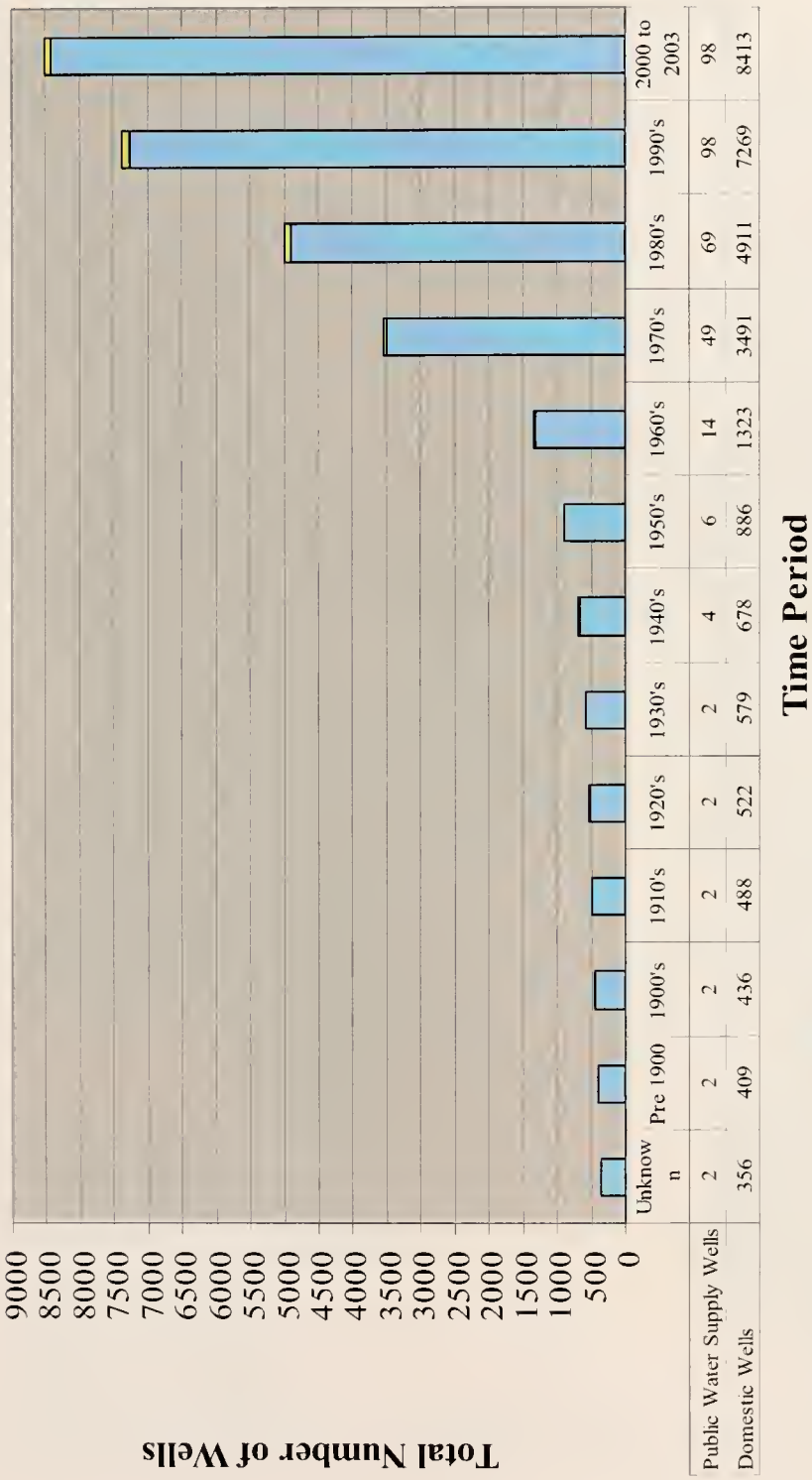


Figure C-7. Granitic geology in the Lake Helena TPA.
Source: Montana State Library Natural Resource Information System, http://nris.state.mt.us/gis/datalist.html, GIS Layer: 1:500,000 scale MBMG Geology



	Unknown	Pre 1900	1900's	1910's	1920's	1930's	1940's	1950's	1960's	1970's	1980's	1990's	2000 to 2003
Public Water Supply Wells	2	2	2	2	2	2	4	6	14	49	69	98	98
Domestic Wells	356	409	436	488	522	579	678	886	1323	3491	4911	7269	8413

Figure C-8. State inventoried wells in the Lake Helena TMDL Planning Area.
Source: Montana State Library Natural Resource Information System, http://nris.state.mt.us/gis/datalist.html, GIS Layer: Ground-Water Information Center Wells

C.4.3 Recommendations for Further Study

Stream dewatering is a common problem in many of the 303(d)-listed segments in the Lake Helena TPA. Reaches of Prickly Pear, Spring, Corbin, North Fork of Warm Springs, Tenmile, Sevenmile, and Silver creeks were observed to be dry or at a critically low stage of flow during the summer of 2003. A detailed hydrologic evaluation and water balance study is needed to decipher the causes of dewatering and to identify ways to optimize instream flows and all beneficial water uses during critical periods of the year.

In 2003, the U.S. Geological Survey in cooperation with the Lower Tenmile Watershed Group initiated a flow study on the lower portion of Tenmile Creek. The group is looking into the possibility of purchasing instream water rights to help maintain stream flows. This past summer, lower Tenmile Creek was surveyed by field crews with GPS units. The location of gaining and losing reaches, irrigation diversions and return flows, major stream bank alterations, major sediment inputs, and weed infestations were documented. More work of this nature is needed for flow-impaired streams in the Lake Helena TPA.

Chronic stream dewatering and other hydrologic modifications can be associated with channel alterations resulting from placer mining, agricultural activities, road construction, and other land uses. Incised stream channels can reduce groundwater elevations of alluvial aquifers and reduce the amount of moisture available to riparian vegetation. Channel alterations and loss of riparian vegetation are common features along many of the 303(d)-listed stream segments in the Lake Helena TPA. A thorough evaluation of these problems is needed, and their influences on water quality and aquatic habitat.

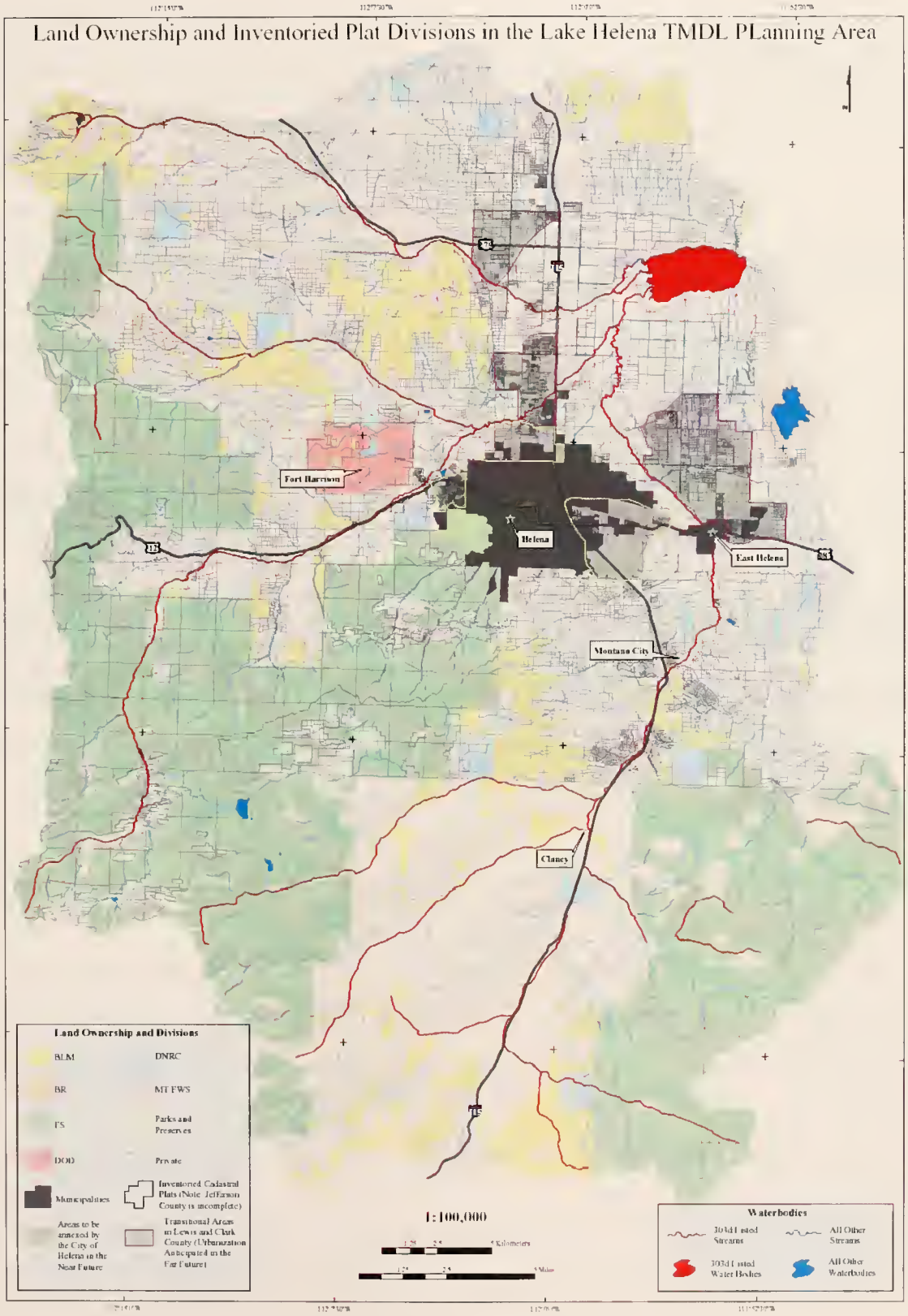


Figure C-9. City-county planning areas and land subdivision in the Lake Helena TPA.

In addition to the recommended hydrologic budget and channel alteration studies, road sediment studies should be conducted for state, county, and private road courses along 303(d)-listed streams, especially unpaved roads. In the summer of 2003, the Helena National Forest conducted road sediment surveys for many forest roads adjacent to 303(d)-listed stream segments within the Lake Helena TPA. The data were used to compute sediment loads to the streams using the WEPP road sediment model (USDA 2004b). The information will be used to prioritize road improvement projects on the Helena National Forest.

An investigation is also warranted of the effects of natural hot springs on water quality along Warm Springs and lower Tenmile Creeks. In addition to elevating water temperatures, hot springs may contain chemical contaminants such as metals. TMDL pollutant allocations will need to reserve loads for these natural sources.

Finally, education is vital for landowners living near streams and within natural floodplains. Using the Lewis and Clark County FEMA flood maps and street address GIS layers, approximately 350 addresses were located within the 100-year floodplain and floodway zones, an additional 809 structures were located in the 500-year floodplain, while another 665 structures were located within Zone C (Lewis and Clark County 2004b). These structures account for about 20 percent of all the structures mapped in Lewis and Clark County. (Note: While Zone C is not officially considered to be a part of the active floodplain, it includes 25 percent of the flood loss claims reported in the county). Similar data were not available for the Jefferson County portion of the Lake Helena TPA.

Landowners living in these areas need to be aware of the risks involved with living in flood prone areas, and actions that can be taken on their part to mitigate damaging impacts to streams and water quality. This will become increasingly important as suburban development continues in riparian areas. Watershed groups are an effective means of informing citizens and generating landowner participation. Currently, only the upper and lower Tenmile watersheds have organized watershed groups, but plans are in the works to establish a Prickly Pear watershed group.

C.5.0 REFERENCES

Carter-Burgess. 2003. Interstate I5 Corridor: Montana City to Lincoln Road, Final Environmental Impact Statement and Section 4(f)/6(f) Evaluation, Volume I. Website at http://www.i-15helenaeis.com/. February 2004.

Jefferson County. 2003. Jefferson County Growth Policy. Jefferson County website at http://www.co.jefferson.mt.us/forms/growthpolicy.pdf. February 2004.

Kendy, E., B. Olsen, and J. C. Malloy. 1998. Field Screening of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Helena Valley, West-Central Montana, 1995. Water-Resources Investigations Report 97-4214. U.S. Geological Survey, U.S. Fish and Wildlife Service, Bureau of Reclamation, and Bureau of Indian Affairs. Helena, MT.

Lewis and Clark County. 2004a. County Growth Policy. Lewis and Clark County website at http://www.co.lewis-clark.mt.us/community/compplan/index.php. February 2004.

Lewis and Clark County. 2004b. Information Technology & Services. Lewis and Clark County website at http://www.co.lewis-clark.mt.us/gis/. February 2004.

Montana Department of Commerce: Census and Economic Information Center. 2003. Population of Counties in Montana, 1890 to 2000 from the U.S. Bureau of the Census, Decennial Censuses of Population. MT DOC website at http://ceic.commerce.state.mt.us/Demog/historic/Censuscounty1890-2000.pdf. February 2004.

Montana Department of Environmental Quality. 2003. Administrative Rules of Montana, Montana Surface Water Quality Standards. Chapter 30, Sub-chapter 6, Rule 17.30.607. DEQ website at http://www.deq.state.mt.us/dir/Legal/Chapters/CH30-06.pdf. June 2003.

Montana Natural Resource Information System. 2003. Montana State Library GIS Data List. NRIS website at http://nris.state.mt.us/gis/datalist.html. August 2003.

Personal Communication. 2004. Foster, J. 2004. Helena Valley Irrigation District.

Rosgen. D., Silvey, H.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Shields, R.R., White, M.K., Ladd, P.B., and Chambers, C.L. 1995. Water resources data, Montana, water year 1994. U.S. Geological Survey Water-Data Report MT-94-1.

U.S. Department of Agriculture. 1986. Helena National Forest, Forest Plan Management Areas. GIS data layer obtained in December 2003.

U.S. Department of Agriculture. 2004a. Helena National Forest, Forest-wide Travel Planning: Proposed Action Scoping Letter. HNF website at http://www.fs.fed.us/r1/helena/projects/tp_revision.shtml. January 2004.

U.S. Department of Agriculture. 2004b. Rocky Mountain Research Station, Moscow Forestry Sciences Laboratory, Soil and Water Engineering Project: Erosion Modeling, FS WEPP (Water Erosion

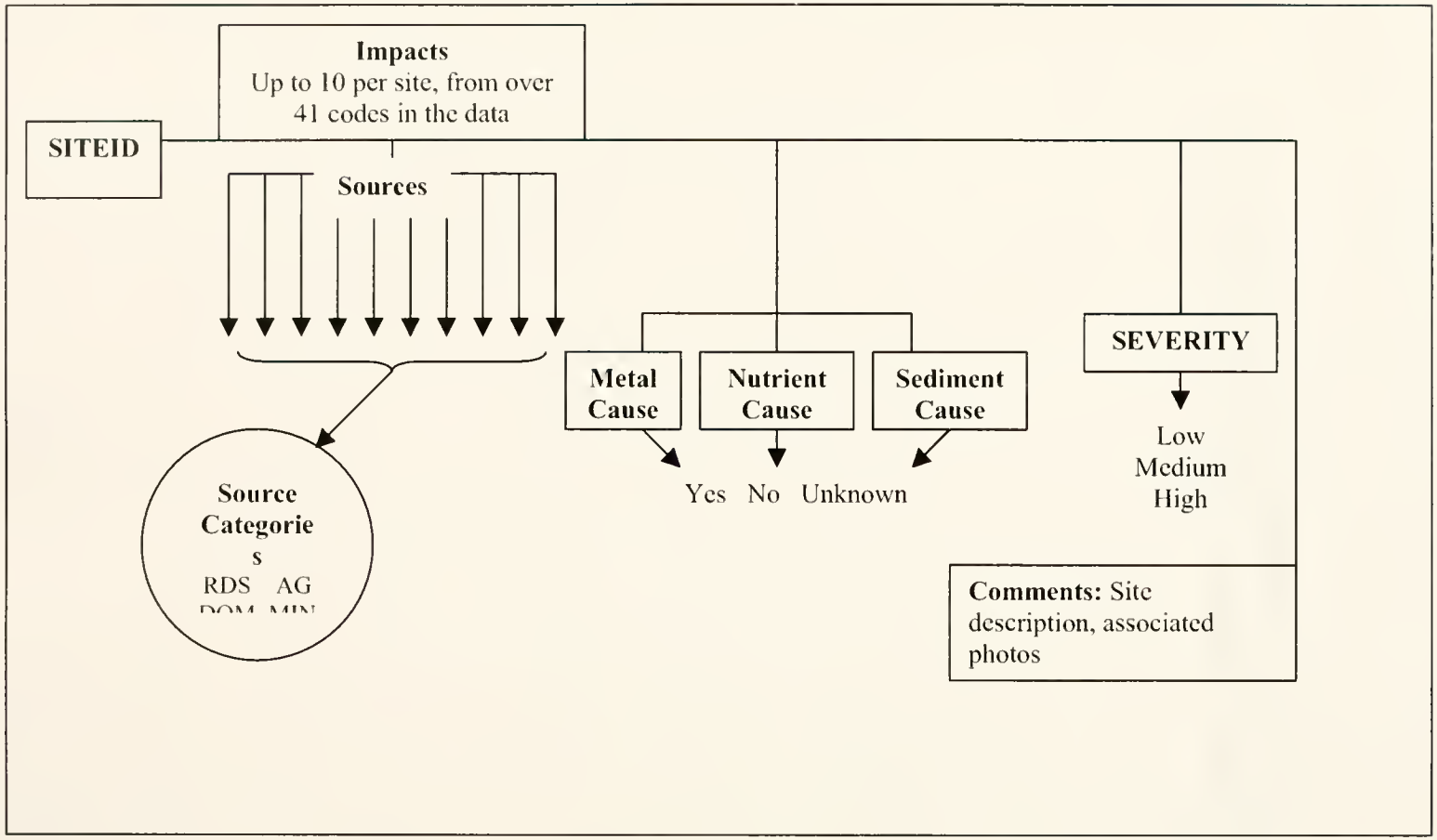
Prediction Project interfaces). USFS RMRS website at http://forest.moscowfsl.wsu.edu/software.html. February 2004.

U.S. Department of the Interior. 2004. Bureau of Land Management. Personal communication with Long, H., for BLM land management strategies in the Lake Helena TPA. January 2004.

USGS. 2004. National Water Information System [Online]. U. S. Geological Survey. Available at http://waterdata.usgs.gov/nwis/.

Source Assessment Part 2:
GPS Source Assessment Data Dictionary

Lake Helena TMDL Planning Area: GPS Source Assessment Data Dictionary Conceptual Diagram



SITEID – This is a text field for the unique id of each position collected (something like PPS1 would be appropriate for Prickly Pear sediment site 1).

Impacts (up to 10 Sources) – These are dropdown tables from which to choose:

Type	Description
ACF	Animal confinement lots
ADT	Adit discharge
BIMP_RR	Bank impairment, rip rap
BIMP_TR	Bank impairment, trampling
BIMP_TW	Bank impairment, trash/waste dump
BIMP_VR	Bank impairment, vegetation removal
BP_EXC	Borrow Pit, Excavation
CFD	Cultivated fields
CHNL_ER	Channel impairment, eroding banks
CHNL_IN	Channel impairment, incisement
CLVT_PRB	Problem Culvert
CNB	Construction building site
CNE	Construction excavation site
CSTR_F	Forest/BLM (etc.) road construction
CSTR_R	Rural road construction
CSTR_S	Subdivision road construction
CSTR_U	Urban road construction
DSB	Dry Stream Bed
EGOL	Highly erosive rocks
ERO_CF	Cut/Fill slope erosion
ERO_T	Tread erosion
ESOL	Highly erosive soils
GZP	Grazing Pasture
IRR_DIV	Irrigation diversion
IRR_RET	Irrigation return flow
MDP	Mine dump/tailings pile
MNT_BR	Bridge maintenance
MNT_GN	General maintenance
MNT_SW	Snow maintenance
NXW	Noxious Weeds
OTH	Other
OVRGZP	Over Grazed Pasture
RDC_ALG	Road Crossing/ Alignment
SEDDV	Sediment Delivery Point
SFRD	Stream Ford
SMP	Suspected mine seepage
SRALT_CH	Stream alteration, channelization
SRALT_D	Stream ateration, dike/dam
WW_SPD	Discharge from septic drainfield

Type	Description
WW_STF	Discharge from sewage treatment facility
WW_SWD	Discharge from storm water drain

Severity – This applies to the severity of stream impacts

Low
Med
High

Source Category – This is a dropdown table from which to choose:

RDS	Road related potential pollution sources
NAT	Natural related potential pollution sources
DOM	Domestic waste related potential pollution sources
AG	Ag related potential pollution sources
MIN	Mining related potential pollution sources
MIX	Mix of any of the above related potential pollution sources

Metals Cause
Nutrients Cause
Sediment Cause
These are dropdown tables from which to choose:

Y	Yes
N	No
UNK	Unknown
NA	Not Applicable

Comments - This is a text field limited to 100 characters and is intended for further descriptors, such as, estimating sizes for points

Source Assessment Part 3: Aerial Photo Interpretation, Photo Sources And Results

Listed Segment	Reach_ID	Description (u/s to d/s)	Source
Upper Prickly Pear_060	PP60_R1	headwaters to FS administrative bdy	USFS July 1999 true color stereo aerial photos, 1:15,840
Upper Prickly Pear_060	PP60_R2	FS administrative bdy to Spring Ck	USFS July 1999 true color stereo aerial photos, 1:15,840 & USGS 1995-1997 black and white DOQs, 1:24,000 using GIS
Golconda_070	GC70_R1	listed segment	USFS July 1999 true color stereo aerial photos, 1:15,840
Corbin_090	CB90_R1	listed segment	USGS 1995-1997 black and white DOQs, 1:24,000 using GIS
Spring_080	SP80_R1	listed segment	USGS 1995-1997 black and white DOQs, 1:24,000 using GIS
Prickly Pear_050	PP50_R1	listed segment	USGS 1995-1997 black and white DOQs, 1:24,000 using GIS
Warm Springs_110	WS110_R1	listed segment	USFS July 1999 true color stereo aerial photos, 1:15,840 & USGS 1995-1997 black and white DOQs, 1:24,000 using GIS
N Fk Warm Springs_180	NWS180_R1	listed segment	USFS July 1999 true color stereo aerial photos, 1:15,840
M Fk Warm Springs_110	MWS110_R1	listed segment	USFS July 1999 true color stereo aerial photos, 1:15,840
Clancy_120	CL120_R1	beginning of listed segment to Quartz Creek	USFS July 1999 true color stereo aerial photos, 1:15,840
Clancy_120	CL120_R2	Quartz Creek to Kelly Gulch	MT DOT 1980 black and white stereo aerial photos, 1:6,000
Clancy_120	CL120_R3	Kelly Gulch to mouth	MT DOT 1980 black and white stereo aerial photos, 1:6,000
Lump Gulch_130	LG130_R1	Headwaters to just before 1st clearcut along stream (where aspect changes from N/S to E/W)	USFS July 1999 true color stereo aerial photos, 1:15,840
Lump Gulch_130	LG130_R2	where aspect changes from N/S to E/W to FS administrative bdy	USFS July 1999 true color stereo aerial photos, 1:15,840
Lump Gulch_130	LG130_R3	FS administrative bdy to Little Buffalo Gulch	USFS July 1999 true color stereo aerial photos, 1:15,840
Lump Gulch_130	LG130_R4	Little Buffalo Gulch to mouth	USFS July 1999 true color stereo aerial photos, 1:15,840 & USGS 1995-1997 black and white DOQs, 1:24,000 using GIS
Prickly Pear_040	PP40_R1	beginning of listed segment to MT City (canyon like)	MT DOT 1997 black and white stereo aerial photos, 1:24,000
Prickly Pear_040	PP40_R2	MT City to Wylie Drive	MT DOT 1997 black and white stereo aerial photos, 1:24,000
Jackson_190	JK190_R1	listed segment	USFS July 1999 true color stereo aerial photos, 1:15,840

Listed Segment	Reach_ID	Description (u/s to d/s)	Source
Prickly Pear_030	PP30_R1	listed segment	MT DOT 1997 black and white stereo aerial photos, 1:24,000
Prickly Pear_020	PP20_R1	listed segment	MT DOT 1997 black and white stereo aerial photos, 1:24,000
Tenmile_141	TM141_R1	Headwaters to Monitor Creek	USFS July 1999 true color stereo aerial photos, 1:15,840
Tenmile_141	TM141_R2	Monitor Creek to end of listed segment	USFS July 1999 true color stereo aerial photos, 1:15,840
Tenmile_142	TM142_R1	beginning of listed segment to conf of Deer Creek	USFS July 1999 true color stereo aerial photos, 1:15,840
Tenmile_142	TM142_R2	Deer Creek to valley opening	USFS July 1999 true color stereo aerial photos, 1:15,840
Tenmile_142	TM142_R3	valley opening to end of listed segment	USFS July 1999 true color stereo aerial photos, 1:15,840
Tenmile_143	TM143_R1	beginning of listed segment to opening of P.P. valley (William St)	USFS July 1999 true color stereo aerial photos, 1:15,840 & MT DOT 1997 black and white stereo aerial photos, 1:24,000
Tenmile_143	TM143_R2	opening of P.P. valley to mouth	MT DOT 1997 black and white stereo aerial photos, 1:24,000
Skelly Gulch_220	SG220_R1	Headwaters to East Skelly Gulch	USFS July 1999 true color stereo aerial photos, 1:15,840
Skelly Gulch_220	SG220_R2	East Skelly Gulch to mouth	USFS July 1999 true color stereo aerial photos, 1:15,840
Sevenmile_160	SV160_R1	beginning of listed segment to Austin Rd crossing	MT DOT 1997 black and white stereo aerial photos, 1:24,000
Sevenmile_160	SV160_R2	Austin Rd crossing to mouth	MT DOT 1997 black and white stereo aerial photos, 1:24,000
Jennies Fk_210	JF210_R1	listed segment	USGS 1995-1997 black and white DOQs, 1:24,000 using GIS
Silver_150	SL150_R1	beginning to listed segment to valley opening	MT DOT 1997 black and white stereo aerial photos, 1:24,000
Silver_150	SL150_R2	valley opening to Green Meadow Drive	MT DOT 1997 black and white stereo aerial photos, 1:24,000
Silver_150	SL150_R3	Green Meadow Drive to end of listed segment	MT DOT 1997 black and white stereo aerial photos, 1:24,000

Reach ID	Stream Length (ft) (Thalweg)	Ownership	Land Use P - Primary, S - Secondary, T - Tertiary	Bed Slope Headwaters	Bed Slope O - Overall HW - Headwaters Lower - Lower Valley	Sinuosity	Riparian Buffer (ft)	Canopy Density	Stability (Signs of bank failure)	Fine sediment % Channel width (RB)	Road Crossings	Diversions	Sed. Source	Notes
PP60_R1	17711	80% USFS	P - Forest rec roads	O - 0.08, HW - 0.12, Lower - 0.06	1.1	extensive in HW in meadow areas ranges from 80-120	thick conifer forest 70-100%			RE 27% (RB 4865)	1	1 (for pond on inholding)	roads, geology	USFS road follows stream course for almost entire length (not in steep headwaters). Wetland observed where flow becomes noticeable on AP, on RB just over 1 mile dis from headwaters. Rosgen stream type from A to B, few unconfined sections (C).
		20% Private	S - Rural housing (~3 houses close to flood plain)											
PP60_R2	19789	60% Private	P - Rural housing (~10 houses close to flood plain)	O - 0.04, Upper - 0.06, Lower - 0.02	1.1	tendency to decrease dis., range from 60 to 130	40-70% in conifers, 20-40% in willows brush			CH: 8% from 115, RE 33% (RB 5904, LB 6135)	7		roads, geology	Some old logging on State land, old clear-cut on private. Major scarring at site of old dredge boat operation. Dispersed housing increases after I15 road crossing. Beaver ponds visible in portion after I15 crossing. Rosgen stream type from B to altered C. Lower portion has been straightened and incised due to placer mining and highway (should be a C along I15 stretch).
		30% State	S- Forest rec roads											
		10% BLM												
G070_R1	12634	84% BLM	P - Forest extraction (timber, mine)	O - 0.15, HW - 0.18, Lower - 0.10	1.1	extensive in HW, areas where there are roads or houses ranges from 50-120	40-70% in conifers			RE 20% (LB: 1615, RB: 953)	2		roads, geology, upslope logging and mining operations	Old mining and clear cut operations on tributary streams to the west of main stem with high road densities. Old mining operations visible on main stem. Rosgen stream type from Aa to Ba.
		16% Private	S - Rural housing (~3 houses close to flood plain)											
SP60_R1	9100	100% Private	P - Pasture	0.02	1	virtually absent, where present <30ft	0-30% deciduous shrubs	incised, headcutting observed in field at mouth		CH: 100% RE 14% (LB: 1249)	3		roads, pasture, and mining operations	Stream segment is basically a ditch with virtually no natural meanders present (slight bend where captures tributary stream). In upper part of segment, tributary streams flow parallel to segment and are very sinuous. Earthwork visible from mine reclamation (Corbin Plant). Channelized due to placer mining and flow through town. Stream does not conform to Rosgen stream type, probably would be an E or a C
			S - Town site (~5 houses close to flood plain)											
CB90_R1	13172	97% Private	P - Grazing, extraction (historic)	O - 0.08, HW - 0.11, Valley - 0.04	1	really only visible in headwaters, ranges from 60 to 185	0-30% conifers	incised after first road crossing, exposed banks and excessive sediment deposition		RE 17% (LB: 1864, RB: 390)	6		roads, pasture, geology, and mining operations	Field source assessment started up southern most tributary, photo assessment up northern most tributary. Headwaters are steep, straight with old prospect sites the only visible sources. After first road crossing, stream begins to look impacted with exposed banks, excessive sediment, and little to no riparian vegetation. Stream looks channelized through town of Corbin. Rosgen stream type Aa to altered B and C reaches (mine reclamation has altered morphology).
		3% BLM	S - Town site (~5 houses close to flood plain)											

Reach ID	Stream Length (ft) (Thalweg)	Ownership	Land Use P - Primary, S - Secondary, T - Ternary	Bed Slope O - Overall HW - Headwaters	Sinuosity	Riparian Buffer (ft)	Canopy Density	Stability (depositional, incising)	Fine sediment in Channel bed (%)	Road Density	Diversions	Sediment Source	Notes
P950_R1	37815	92% Private	P - Transportation corridor	0.01	1.1	variable and correlated to distance from roads, range from 30 to 110	10-70% deciduous trees and shrubs	incised from placer mining	CH: 91%	16 (4 x under I15)		roads, pasture	Prairie much entire reach channelized by I15 and runs between I15, frontage roads, and a decommissioned railroad. Large berm about 3-4 miles in segment forces stream to go east under I15 when the stream wouldn't naturally bend. There is evidence of the channel continuing on the west side of the highway for almost 1/2 mile. In many instances the road corridor is 4x that of the riparian corridor. Stream does not totally conform to Rosgen stream type, but has some characteristics of C and F channels. Should be a C.
		8% State	S - Rural housing (~10 houses close to flood plain)										
NWS180_R1	7906	80% USFS	P - Forest roadroads	0.09	1.1	extensive in conifer forest, sparse on private lands (35ft)	40-70% conifers, 0-30% private		RE: 26% (RB: 2025)	2		roads, geology, (grazing and logging on private)	Stream looks relatively unimpacted, except for small parcel of private land where there is evidence of a small clear cut and grazing close to the stream. Rosgen stream type Aa to Ba, one section of C on private property.
		20% Private	S - Rural housing (1 house close to flood plain)										
MWS100_R1	9950	80% USFS	P - Forest extraction (lumber, mine)	0.08	1.1	extensive in conifer forest, except for 1200 ft along stream where mine tailings have prevented growth of riparian vegetation	75% conifers, 0-10% mine dump	not noticeable on photos, dense vegetation, except for mine tailings spot where stream course is altered	RE: 56% (RB: 5758)	2		roads, geology, and mining operations	Stream heavily impacted by road network, with almost the entire length of stream encroached by the road network. Large mine dump in the middle of stream is probably a source of metal laden fines. Heavy logging has occurred on hillslopes of private lands above stream. Rosgen stream type Aa to B and a few unconfined sections (C) (mine reclamation has altered morphology).
		20% Private											
WS110_R1	16097	100% Private	P - Rural housing (~20 houses close to flood plain)	0.02	1.2	variable depending on landowner, ranges from 30 to 145	upper 3/4 mi of listed segment 30-55%, lower portion 60-75% deciduous shrubs and trees	stream is depositing excessive sediment from beginning of listed segment to 1.3 mi d/s	CH: 8% from W/S Road and I15 frontage road, RE: 4% (RB: 631)	11		roads, development, geology, and pasture	Floodplain has extensive rural home development, but most of stream course is allowed to meander naturally with the exception of road crossings. Deposition of excessive sediment at beginning of segment is probably a combination of the confluence of drainages, slope decrease, and development. Rosgen stream type mostly C with some sections of B.
CE120_R1	17624	100% Private	P - Grazing extraction (historic)	O - 0.06, HW - 0.10, Lower - 0.05	1.1	extensive in conifer forest, range from 15 to 95 where deciduous canopy	70% conifers, 0-40% deciduous brush and trees		RE: 46% (RB: 4904, LB: 3158)	2		mining operations, roads, geology, and pasture	Mt Tinnel Mine in headwaters, some runoff certain to enter creek as area below pit has poor protection (no trees, little buffer). Many smaller mine dumps in upper tributaries (~7) with 1 in stream course just below beginning of listed segment. Beaver ponds 1.5 mi d/s with good density of riparian vegetation. Confluence with some creek from Greenery Mtn. area very barren with sparse riparian vegetation, continuing d/s for rest of reach. Rosgen stream type A to altered C and B reaches (mining, reclamation, and beaver ponds have altered morphology).
			S - Forest road										

Reach ID	Stream Length (ft) (Thalweg)	Ownership	Land Use P - Primary, S - Secondary, T - Tertiary	Bed Slope O - Overall HW - Headwaters	Sinuosity	Riparian Buffer (ft)	Canopy Density	Stability (depositional, incised)	Road Encroachment (channelization) (ft)	Road Crossings	Diversions	Sed_Sources	Notes
CL120_R2	17672	92% Private	P - Hay fields, pasture, and rural housing (~5 houses close to flood plain)	0.02	1.1	extensive in conifer forest, maximum of 50 in placer mined and tilled areas	variable 0-70%	stream incised, widened, deepened and channelized from placer mining	CH: 55% from placer mining in stream	1		mining operations, roads, geology, and hay fields/pasture	Reach begins in a hayfield where riparian vegetation is only a thin strip. Stream name enters a bit of flow from Quartz creek. Clear cut logging has occurred in hills to south of stream. About 3/4 mile in reach, drainage is deranged with numerous channel threads for about 1000 feet and is possibly an old mill or dam site. Large placer mining operations in stream with tailings piles lined on both sides of stream. Trees are now growing in tailings piles. Of the listed streams, placer mining and tailings are most extensive on Clancy Creek. Prickly Pear might have been worse but I15 construction probably dealt with a lot of the workings. Rosgen stream type C to altered sections of B
		8% BLM	S - Extraction (lumber, historic mining)										
CL120_R3	26971	88% Private	P - Hay fields, pasture, and town site (~5 houses close to flood plain)	0.02	1.1	variable, extensive in small portions of conifer forest, placer mined and tilled areas ranges from 0 to 115	0-70% conifers, and deciduous trees and shrubs	stream incised, widened, deepened and channelized from placer mining	CH: 40% from placer mining in stream and small portion for I15		3 diversions	mining operations, roads, geology, and hay fields/pasture	Reach begins in relatively unimpacted stretch with dense conifers. About 1.5 miles encounter private property with 2 structures close to stream and little riparian vegetation. About 1/2 mile encounter hayfield where only a thin strip of riparian vegetation surrounds creek. Hayfields continue for about 4.5 miles. Tailings piles begin again after hayfield. About 3 miles old burn evident in hillslopes, but riparian area has vegetation. In town of Clancy, creek has a thin strip of riparian vegetation with development close to stream. Rosgen stream type altered B to altered C sections.
		12% BLM	S - Extraction (lumber, historic mining)								1 return flow ditch		
JCK190_R1	14015	64% USFS	P - Forest rec roads	O - 0.12, HW - 0.19, Lower - 0.08	1.1	range from 50 to 105, thicker where tributaries enter	10-50% deciduous trees and shrubs		RE: 4% (RB: 537)	10		roads, geology, and old burn	Headwater area has extremely rugged terrain with lots of exposed rock outcrops and rockslides. Whole drainage was burned over in Warm Springs fire of 1988. Most green growth in watershed is confined to riparian areas. High density of roads in watershed crisscrosses stream (salvage logging?). Rosgen stream type Aa to Ba
		45% Private	S - Rural housing (~3 homes close to flood plain)										
LG130_R1	4876	99% USFS	P - Forest rec	0.09	1.1	extensive	70-100% conifers		none	none			Small segment appears relatively unimpaired and probably shouldn't be listed. Rosgen stream type Aa.
		1% Private											

Reach ID	Stream Length (ft) (Thalweg)	Ownership	Land Use P - Primary, S - Secondary, T - Tertiary	Bed Slope (% Over full length)	Sinuosity	Riparian Buffer (ft)	Canopy Density	Stability (de-pendent on weather)	Road Encroachments (Channelization) (ft)	Road Crossings	Diversions	Sediment Sources	Notes
LG130_R2	23707	90% Private	P - Forest extraction (logging, historic mining)	0.05	1	extensive where conifers, ranging from 70 to 150 in deciduous trees and shrubs	70-100% conifers, 0-30% in deciduous trees and shrubs		RE: 6% (RB: 1464)	2		mining operations, roads, geology, and logging	First opening along stream is in old clear cut meadow where the stream is deranged from Frohner Meadows Mine. Extensive clear cutting in drainage with a large associated road system network. Tributary draining from Park Lake has a series of dammed structures. Mine dumps visible in hillslopes above stream. Reach ends at a beaver pond complex. Rosgen stream type altered C to altered B and C (mining has altered morphology).
		10% USFS	S - Rural housing (~3 houses close to flood plain)										
LG130_R3	22681	55% Private	P - Forest not roads	0.04	1.1	extensive where conifers, ranging from 55 to 100 in deciduous trees and shrubs	70-100% conifers, 0-30% in deciduous trees and shrubs		RE: 53% (RB: 1935, LB: 10141)	7		roads, geology	Reach begins in beaver complex where stream splits channel and deposits sediment. Another depositional area is noted after stream exits small 'canyon'. Stark increase in housing development about 1.3 miles from Park Lake runoff, with many driveways crossing stream and housing in floodplain. Rosgen stream type mostly B (mining has altered morphology).
		40% BLM	S - Rural housing significant increase d/s (~10 houses near flood plain)					sediment deposition					
		5% State											
LG130_R4	18225	85% Private	P - Rural Housing (~20 houses near flood plain)	0.01	1.1	tendancy to decrease d/s with increase in tilled fields, range from 40 to 140	30-65% deciduous trees and shrubs		RE: 11% (RB: 893, LB: 589, Both: 390)	8		roads, geology, and hay fields/pasture	Loss of housing development in the floodplain. Roads constrict stream. Increase in agricultural land closer to the mouth with cultivation close to the stream and removal of riparian vegetation. Rosgen stream type B to C (mining and roads have altered morphology).
		9% State	S - Forest road, Hay fields and pasture										
		6% BLM											
PS45_R1	30884	77% Private	P - Transportation corridor	0.01	1.1	variable and correlates to distance from roads, range from 0 to 390	0-70% deciduous trees and shrubs	sediment deposition	CH: 51% from I15, frontage roads, and RR	9		roads, exposed stream banks	Segment begins at mouth of Lump Gulch with first 1/2 mi surrounded by farmland. Stream is heavily impacted by roads with long sections channelized and in some areas only 60 to 70 feet for stream to flow between roads. Subdivision development notable in hillslopes. Stream does not totally conform to Rosgen stream type, but has some characteristics of C and F channels. Should be a C.
		23% BLM	S - Subdivisions, rural housing (~10 houses near flood plain)										

Reach ID	Stream Length (ft) (Thalweg)	Ownership	Land Use P - Primary, S - Secondary, T - Ternary	Bed Slope 0 - Overall Hills Headwaters	Sinuosity	Riparian Buffer (ft)	Canopy Density	Stability (deposition, incision)	Encroachment (channelization) (ft)	Road Crossings	Diversions	Sed. Sources	Notes
PP40_R2	26225	100% Private	P - Transportation corridor	0.01	1.1	ranges from 0 to 200	0-70% deciduous trees and shrubs	sediment deposition	CH: 63% from highway, RR, ASARCO, and E. Helena	8	1 diversion	roads, hay fields pasture	Reach is constricted and channelized at times between highway and railroad. Two large mining operations in watershed segment at Montana City and E. Helena. Gravel bars visible in stream. Notable increase in flow volume after confluence with McCellan Creek. Confluence with Helmet Gulch (large placer tailings line gulch) marks channel splitting in two segments for about 1.3 mi. Just before segment ends, stream is diverted by two canals into a wetland holding pond for ASARCO (1 of 2 ponds). Segment passes through ASARCO dam and flows by slag pile and then under highway 12/287. There doesn't appear to be anything to prevent slag from entering stream. Houses in E. Helena are close to stream. About 1.5 mi before Wylie Dr. road crossing, stream splits into 2 segments with the RB channel dry. Stream does not totally conform to Rosgen stream type, but has some characteristics of C and F channels. Should be a C.
			S - Rural housing (no houses close to floodplain), industry (mine)										
PP30_R1	26422	100% Private	P - Hay fields, pasture	0.01	1.2	ranges from 0 to 230	0-40% deciduous trees and shrubs		CH: 30% from irrigation diversions and gravel mine	5	2 diversions	hay fields pasture, roads, exposed stream banks	Segment borders at Wylie Drive. There is evidence in the vicinity of 2 or 3 old channel beds (natural split?). Segment flows through Helena Valley irrigation canal and then passes a large gravel mining operation. Channelization is evident from irrigation diversions and gravel mining operation. Many gravel bars present in stream. Sinuosity starts to look more natural after Canyon Ferry Rd crossing. Stream starts gaining flow about 5.6 mi after Canyon Ferry Rd crossing. Stream does not totally conform to Rosgen stream type, but has some characteristics of C and F channels. Should be a C.
			S - Industry (gravel mine)										
PP20_R1	33096	100% Private	P - Hay fields, pasture, and rural homes (~10 houses near flood plain) /	< 0.01	2.1	ranges from 0 to 215	0-50% deciduous trees and shrubs	sediment deposition		8 (4 foot bridges)	1 diversion	hay fields/pasture, exposed stream banks, roads	Stream sinuosity looks fairly natural and has good flow. Sewage lagoon behind police academy fairly close to stream (350 ft). After confluence with Tenmile, failing stream banks evident in areas with little to no riparian vegetation. Probably a good candidate area for conservation as area has high ground water levels. Unlike Silver Creek, stream discharges into lake in a natural deltaic fron (distributary). Sediment deposition in lake visible. Rosgen stream type C and F.
			S - Industry								6 return flow ditches, including WWTP ditch		
JF210_R1	7204	100% Private	P - Forest rec roads	O - 0.15, HW - 0.15	1	extensive in forested areas, ranging from 0 to 110 in meadow areas	40-70% in forested areas	sediment deposition	RB: 56% (RB: 1670, LB: 2351)	4		roads, ski runs, zoology, and grazing	There is an extremely high density of roads in watershed, especially at the ski resort. There are roads along the entire length of the stream except for a small segment near Marysville. Less than half of the stream has good riparian vegetative cover. An old adit is visible on the hillslope above the stream near Marysville. Rosgen stream type Aa to B.
			S - Town site (no houses near flood plain)										

Reach ID	Stream Length (ft) (Thalweg)	Ownership	Land Use P - Primary, S - Secondary, T - Tertiary	Headwater Slope / Valley Slope / Overall	Sinuosity	Riparian Buffer (ft)	Canopy Density	Stability (deposition, incision)	Road Encroachment or Channelization (ft)	Road Crossings	Diversions	Sediment Sources	Notes
SLV150_R1	36336	97% Private	P - Forest extraction roads	C - 0.04, Upper - 0.06, Lower - 0.03	1.1	fairly extensive in upper part of segment, once first mill site is reached ranges from 0 to 300	conifers 50-70%, deciduous vegetation 0-40%	stream incised, widened, deepened and channelized from placer mining	CH: 52% from placer mining in stream	7		mining operations, roads, and geology	Segment begins just above Marysville. There are lots of secondary roads in the hills to the south of the stream associated with mining activities, with large scars visible in the hillside across from Marysville. Marysville road is on a steep slope to the north of stream and roughly follows stream course. Just below confluence with China Gulch, the lack of riparian vegetation begins at the Drumlummon Mill Site. At the second mill site below China Gulch, Goldsil, major excavation of the stream begins and there are ponds where the water table has been intersected. There is only a thin strip of riparin vegetation between the stream and mill site. The placer mining at times splits the stream course in two. Placer tailings line the banks of the excavated channel and have been deposited in the fields surrounding the dredge operations. There is extensive ponding on the last 1/3 mi of reach, which could be from beaver ponds or mining dams. Below mill operations, stream does not conform to Rosgen stream type probably would transition from a B to a C.
		3% BLM	S - Town site (~3 houses near flood plain)										
SLV150_R2	44580	100% Private	P - Hay fields, pasture, and rural housing (~10 houses near flood plain)	0.01	1.2	ranges from 0 to 130	0-30% varies by landowner, deciduous trees and shrubs		RE: 5% (LB: 2094)	9	13 diversions	hay fields/pasture, exposed stream banks	Noticeable increase in stream sinuosity. Segment is ponded at the first railroad crossing and split channel into about 3 segments. Areas of stream look straightened for irrigation purposes. Biggest impacts to stream segment appear to be irrigation withdrawals and farming to within a thin strip of riparian vegetation. Rosgen stream type is a straightened C, possibly F in some sections.
											5 return flow ditches		
SLV150_R3	28294	100% Private	P - Hay fields, pasture, and rural housing (~5 houses near flood plain)	0.01	NA because of CH and stream going underground	overall 0	overall 0		CH 100%	14	11 diversions	hay fields/pasture, exposed stream banks, and roads	Stream becomes distributary at Green Meadow Dr. After crossing Green Meadow Dr., entire stream course is channelized in irrigation ditches and doesn't really appear as a stream again until just before entering Lake Helena. Between Green Meadow Dr. and Applegate Dr. stream canal intersects Helena Valley Irrigation Canal. Stream goes subterranean about 3 mi d s of Green Meadow Dr. in an irrigation pipe after crossing I-15, and also where the stream intersects a large canal which drains into Lake Helena. Because of channelization, stream does not conform to Rosgen stream type but would probably have been a C.
											4 return flow ditches		
			S - Subdivisions (>50 houses near stream canal)										

Reach ID	Stream Length (ft) (Thalweg)	Ownership	Land Use P - Primary, S - Secondary, T - Tertiary	Bed Slope O - Overall HW - Headwaters	Sinuosity	Riparian Buffer (ft)	Canopy Density	Stability (depositional, intermediate)	Road Encroachment (Intermediate stream) (ft)	Road Crossings	Diversions	Sed. Sources	Notes
TM143_R1	36-84	100% Private	P - Hay fields, pasture, and rural housing (~20 houses near flood plain)	0.01	1.1	from 55 to 200	40-70% deciduous trees and brush		CH: 22% from Hwy 12 and irrigation diversion	12	7 diversions	hay fields/pasture, exposed stream banks, and roads	There is a large gravel mining operation about 1/4 mi d/s from WTP, which has intercepted the water table. Lots of ponds are along reach with grazing and having occurring in the riparian area. Stream is gaining flow. Exposed stream banks visible. Biggest impacts to stream appear to be agriculture (channel alterations for irrigation diversions and lack of riparian vegetation), and channelization from Hwy 12 (excess stream energy visible in meander bend avulsion). 1.3 mi before end of reach a major irrigation diversion (Sliam) alters stream course by splitting the channel and cutting off a meander. Rosgen stream type straightened, mixed C.
											4 return flow ditches		
			S - Industry (mining)										
TM143_R2	49952	100% Private	P - Hay fields, pasture, and rural housing (~10 houses near flood plain)	0.01	1.3	from 0 to 230	0-40% deciduous trees and shrubs		CH: 11%	10	9 diversions	hay fields/pasture, exposed stream banks, and roads	Increase in development is obvious once reach valley floor, but beginning and end of reach are predominantly ranch lands. Exposed and eroding stream banks are visible. The stream looks straightened for agricultural purposes. Old gravel quarries are close to stream (Spring Meadow State Park). Stream flows through golf course where obvious straightening has occurred, and in places the green is mowed to the edge of the stream bank. After crossing Green Meadow Dr., there is a change of land use to dense subdivision development until I15 crossing. After I15 crossing, sinuosity increases but riparian vegetation decreases towards mouth. Irrigation diversion at I15 appears to severely dewater the channel. Rosgen stream type straightened, mixed C.
			S - Subdivisions (>50 houses close to flood plain)								6 return flow ditches		

Reach ID	Stream Length (ft) (Thalweg)	Ownership	Land Use P - Primary, S - Secondary, T - Tertiary	Bed Slope O - Overall HW - Highest Water	Sinuosity	Riparian Buffer (ft)	Canopy Density	Bank Stability (Erosion Potential)	Channel Distance to Nearest Road (feet)	Road Crossings	Diversions	Bed Source	Notes
SG220_R1	15610	65% USFS	P - Forest extraction (timber, mining) rec	O - 0.08, HW - 0.11, Lower - 0.06	1.1	extensive where no roads or clear cuts, otherwise 55 to 180	70-100% dense conifers		RE: 7% (RB: 1128)	3		roads	Clear cut in headwaters relatively close to RB on USFS lands. Stream at intermittent until ascent change from east-west to north-south. Steep slopes surrounding stream, but good conifer growth (where no harvest). Just before confluence with unnamed tributary about 2 mi d/s, valley bottom opens a bit and more shrubby wetland vegetation is present. Looks like old clear cut on second RB tributary. Fairly high road density in watershed. Rosgen stream type A to B
		35% Private											
SG220_R2	16005	81% Private	P - Rural Housing (~5 houses close to flood plain)	O - 0.03, Upper - 0.04, Lower - 0.03	1.1	range from 40 to 90	50-70% conifers and deciduous vegetation		RE: 27% (RB: 4280)	8	1 for pond	roads, beaver ponds	Hillslopes surrounding stream look very dry. Housing development noticeable just below USFS boundary, but development is not dense. Unpaved road on steep hillside above stream or beside it probably a sediment source. Impoundment on stream for a pond about 1 mi u/s of mouth. A house is built right in the floodplain just d/s of pond. Beaver pond complexes 1.5 miles u/s of mouth and just before mouth. Rosgen stream type B with a few sections of C.
		19% BLM											
			S - Forest rec/roads										
SV160_R1	25752	57% Private	P - Transportation corridor (railway)	0.02	1.2	range from 50 to 275	beginning of segment 50-80%, below RS, owned land 20-50%, deciduous vegetation		CH: 24% from railroad	2	5 diversions	hay fields/pasture	Stream lateral migration hampered by railroad and has been channelized in some sections. Stream is sandwiched between steep hillslopes on south and railroad on north for about first 2 mi of segment. 5 meander cutoffs associated with railroad. Rosgen stream type, straightened C.
		23% BLM	S - Hay fields, pasture, and rural housing (~5 houses near flood plain)										
SV160_R2	21654	100% Private	P - Hay fields pasture, and rural housing (~1 house close to flood plain)	0.01	1.3	range from 0 to 125	0-50% deciduous trees and shrubs	inmixed		3	5 diversions	hay fields/pasture, exposed stream banks	Stream becomes incised with visible eroding stream banks about 2.1-4 mi d/s of Austin Rd crossing. There is a big diversion just below beginning of the noticeable incision. Looks like stream has down dropped ~3 channel widths with trees and brush growing in incised area. After the diversion, the stream is not filling the full channel width. Closer towards mouth, noticeable increase in subdivisions but not proximal to stream. Alluvial fan stream that flows from golf course enters stream just above lower railroad crossing. Rosgen stream type C to incised and altered E.
											5 return flow ditches		
			S - Subdivisions										

Source Assessment Part 4: Summary Of Major Sources By Stream Segment

Lake Helena TMDL Planning Area: Simplified Source Assessment Key

Symbol	Description
ABM	Abandoned Mining (Hardrock and Placer) – includes acid mine drainage; mine, mill, and placer tailings; and mining remnants in the stream and floodplain (walls, dams, equipment, etc.)
AG	Agricultural/Crop Production – non-point source runoff
FR-H	Flow Regulation/Hydromodification - includes water diversions; interbasin transfers; return flows; and disruptions of the natural hydrology due to channel modifications (placer mining, channel reclamation)
GZ-L	Grazing/Livestock – includes trampled banks; riparian degradation; confined feeding operations; and animal wastes
IND	Industrial – includes point source discharges and construction activities related to industry
MUN	Municipal – includes municipal point source discharges; storm runoff, and activities related to municipal use
NAT	Natural Sources – includes erosive soils and geology; fire effects; hot springs; beaver dams; and dams installed before 1971
RDM	Road, Highway, Bridge Construction and Maintenance – includes sediment delivery; channel encroachment; stream channelization; and bank alterations resulting from roads, highways, and bridges
S-LD	Subdivisions/Land Development – includes storm runoff; riparian degradation; channel encroachment; bank and channel alterations; and the potential for nutrient and septic waste contamination resulting from land development

Prickly Pear Creek and Lake Helena Subwatersheds

Segment Name	Segment ID	2003 Surveyed Sources Source: X Source Present: X Major								
		ABM	AG	FR-H	GZ-L	IND	MUN	NAT	RDM	S-LD
Prickly Pear Creek	MT411006_060	X		X	X			X	X	X
Prickly Pear Creek	MT411006_050	X		X	X			X	X	X
Prickly Pear Creek	MT411006_040	X		X		X	X	X	X	X
Prickly Pear Creek	MT411006_030	X	X	X	X	X		X	X	X
Prickly Pear Creek	MT411006_020	X	X	X	X		X	X	X	X
Golconda Creek	MT411006_070	X						X	X	X
Corbin Creek	MT411006_090	X		X	X			X	X	X
Spring Creek	MT411006_080	X		X	X			X	X	X
Middle Fork Warm Springs Creek	MT411006_100	X		X				X	X	
North Fork Warm Springs Creek	MT411006_180	X		X				X	X	X
Warm Springs Creek	MT411006_110	X	X		X			X	X	X
Clancy Creek	MT411006_120	X	X	X	X			X	X	X
Lump Gulch	MT411006_130	X	X	X	X			X	X	X
Jackson Creek	MT41I006_190							X	X	
Lake Helena	MT411007_010		X	X	X		X	X		X

Tenmile Creek Subwatershed

Segment Name	Segment ID	2003 Surveyed Sources Source: X Source Present: X Major								
		ABM	AG	FR-H	GZ-L	IND	MUN	NAT	RDM	S-LD
Tenmile Creek	MT41I006_141	X		X				X	X	
Tenmile Creek	MT41I006_142	X		X				X	X	X
Tenmile Creek	MT41I006_143	X	X	X	X	X	X		X	X
Skelly Gulch	MT41I006_220	X			X			X	X	X
Sevenmile Creek	MT41I006_160	X	X	X	X		X	X	X	X

Silver Creek Subwatershed

Segment Name	Segment ID	2003 Surveyed Sources Source: X Source Present: X Major								
		ABM	AG	FR-H	GZ-L	IND	MUN	NAT	RDM	S-LD
Jennies Fork	MT41I006_210	X			X			X	X	X
Silver Creek	MT41I006_150	X	X	X	X	X		X	X	X

Appendix D: Nutrient Data for Impairment Status Determination

Water Chemistry Data for Streams

Table 1. Total Kjeldahl Nitrogen Values									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean TKN (mg/L)	Min TKN (mg/L	Max TKN (mg/L)	# of Exceedances
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC 02	DEQ	8/1/01	1	0.4			1
		DEQM09CLNCC 01	DEQ	8/1/2001	1	0.4			1
		DEQM09CLNCC 01	Land and Water	7/15-8/11/03	2	<0.12	<0.10	0.14	0
		M09CLNCC03	Land and Water	7/15-8/11/03	2	<0.11	<0.10	0.12	0
		M09CLNCC04	Land and Water	7/16-8/12/03	2	<0.115	<0.10	13	0
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	M09WSNFC01	Land and Water	7/15/03	1	<0.10			0
		M09WSNFC02	Land and Water	7/15-9/24/04	4	<0.19	<0.10	.17	0
Prickly Pear Creek (from highway 433 crossing to Helena WWTP discharge)	MT411006_030	M09PKPRC05	Land and Water	7/17-8/27/04	3	0.13	0.10	0.14	0
		M09PKPRC01	Land and Water	7/17-8/27/04	3	<0.123	<0.10	0.16	0
Prickly Pear Creek (from Helena WWTP Discharge Ditch to Lake Helena	MT411006_020	M09PKPRC02	Land and Water	7/17-9/24/04	6	0.49	0.30	0.88	5
Sevenmile Creek (from Lake Helena to Hauser Lake)	MT411006_160	463747112033801	USGS	05/02-12/03	8	0.85	0.14	4.8	5
		M09SVNMC01	DEQ	7/30/01	1	1.2			1
		M09SVNMC02	DEQ	7/31/01	1	0.4			1
Spring Creek (from Corbin Cr to the mouth)	MT41006_080	M09SPRGC01	USGS	7/14-9/24/04	6	<0.238	<0.10	0.66	4
Tenmile Creek (from the Helena WT plant to the mouth)	MT411006_143	06064100	USGS	04/02-12/03	8	0.84	0.16	4.6	5
		463438112091801	USGS	04/02-12/03	8	0.305	.09	0.9	3
		06063000	USGS	04/02-12/03	8	0.288	.09	0.8	3
		M09TENMC01	DEQ	7/30/01	1	0.4			1
		M09TENMC02	DEQ	7/31/01	1	0.6			1

Table 2. Total Nitrogen Values									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean TN (mg/L)	Min TN (mg/L)	Max TN (mg/L)	# of Exceedances
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC02	DEQ	8/1/01	1	0.46			1
		DEQM09CLNCC01	DEQ	8/1/2001	1	<0.41			1
		DEQM09CLNCC01	Land and Water	7/15/03-8/11/03	2	<0.155	<0.12	0.19	0
		M09CLNCC03	Land and Water	7/15/03-8/11/03	2	<0.29	0.26	<0.32	0
		M09CLNCC04	Land and Water	7/16/03-8/11/03	2	0.14	0.12	0.16	0
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	M09WSNFC01	Land and Water	7/15/03	1	<0.15			0
		M09WSNFC02	Land and Water	7/15/03-9/24/04	4	<0.25	0.21	0.27	0
Prickly Pear Creek (from highway 433 crossing to Helena WWTP discharge)	MT411006_030	M09PKPRC05	Land and Water	7/17/03-8/27/04	3	<0.21	<0.11	0.34	1
		M09PKPRC01	Land and Water	7/17/03-8/27/04	3	0.64	<0.43	0.77	2
Prickly Pear Creek (from Helena WWTP Discharge Ditch to Lake Helena	MT411006_020	M09PKPRC02	Land and Water	7/17/03-9/24/04	6	2.03	1.9	2.60-	6
Sevenmile Creek (from Lake Helena to Hauser Lake)	MT411006_160	463747112033801	USGS	05/02-12/03	8	1.03	0.264	5.16	6
		M09SVNMC01	DEQ	7/30/01	1	1.21			1
		M09SVNMC02	DEQ	7/31/01	1	<0.41			1
Spring Creek (from Corbin Cr to the mouth)	MT41006_080	M09SPRGC01	Land and Water	7/14/03-9/24/04	6	<0.31	<0.10	1.05	2
Tenmile Creek (from the Helena WT plant to the mouth)	MT411006_143	06064100	USGS	04/02-12/03	8	0.99	0.2	4.9	5
		463438112091801	USGS	04/02-12/03	8	0.552	0.31	1.07	6
		06063000	USGS	04/02-12/03	8	0.54	0.29	1.06	6
		M09TENMC01	DEQ	7/30/01	1	0.41			1
		M09TENMC02	DEQ	7/31/01	1	<0.61			1

Table 3. Total Phosphorus Values

Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean TP (mg/L)	Min TP (mg/L	Max TP (mg/L)	# of Exceedances
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC02	DEQ	8/1/01	1	0.25			1
		DEQM09CLNCC01	DEQ	8/1/2001	1	0.17			1
		DEQM09CLNCC01	Land and Water	7/15/03-8/11/03	2	0.027	0.018	0.035	1
		M09CLNCC03	Land and Water	7/15/03-8/11/03	2	0.010	0.006	.013	0
		M09CLNCC04	Land and Water	7/16/03-8/12/03	2	0.010	0.005	0.012	0
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	M09WSNFC01	Land and Water	7/15/03	1	0.030			1
		M09WSNFC02	Land and Water	7/15/03-9/24/04	4	0.026	0.020	0.033	2
Prickly Pear Creek (from highway 433 crossing to Helena WWTP discharge)	MT411006_030	M09PKPRC05	Land and Water	7/17/03-8/27/04	3	0.030	0.027	0.030	1
		M09PKPRC01	Land and Water	7/17/03-8/27/04	3	0.030	0.014	0.049	1
Prickly Pear Creek (from Helena WWTP Discharge Ditch to Lake Helena	MT411006_020	M09PKPRC02	Land and Water	7/17/03-9/24/04	6	0.558	0.345	0.797	6
Sevenmile Creek (from Lake Helena to Hauser Lake)	MT411006_160	463747112033801	USGS	06/97-12//03	11	0.065	0.03	1.61	11
		M09SVNMC01	DEQ	7/30/01	1	0.163			1
		M09SVNMC02	DEQ	7/31/01	1	0.054			1
		SMC1	DEQ	7/1/97	1	0.15			1
Spring Creek (from Corbin Cr to the mouth)	MT41006_080	M09SPRGC01	Land and Water	7/14/03-9/24/04	6	0.053	0.009	0.205	3
Tenmile Creek (from the Helena WT plant to the mouth)	MT411006_143	06064100	USGS	06/97-12/03	12	0.16	0.01	1.49	9
		463438112091801	USGS	06/97-12/03	12	0.05	.013	.22	9
		06063000	USGS	05/97-10/02	11	0.04	.008	0.21	5
		06064150	USGS	06/97-/10/02	3	.043	.03	.06	3
		M09TENMC01	DEQ	7/30/01	1	0.029			1
		M09TENMC02	DEQ	7/31/01	1	0.048			1
		TMC1-WTP	DEQ	7/97	1	0.02			
		TMC3-WSB	DEQ	7/97	1	0.03			1
		TMC5-SRE(PPC)	DEQ	7/97	1	0.06			1

Supplemental Indicators for Streams

Table 4. Chlorophyll *a*									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean Chlorophyll *a* (mg/m2)	Min Chlor *a* (mg/m2)	Max Chlor *a* (mg/m2)	# of Exceedances
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC01	Land and Water	7/15/03-8/11/03	3	18	5.0	40.4	1
		M09CLNCC03	Land and Water	7/15/03-8/11/03	1		20		0
		M09CLNCC04	Land and Water	7/16/03-8/12/03	2	16.8	13.8	19.8	0
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	M09WSNFC01	Land and Water	7/15/03-8/12/03	1		27.7		0
		M09WSNFC02	Land and Water	7/15/03-9/24/04	4	33.33	26	41	2
Prickly Pear Creek (from highway 433 crossing to Helena WWTP discharge)	MT411006_030	M09PKPRC05	Land and Water	7/17/03-8/27/04	3	37.3	20	51	2
		M09PKPRC01	Land and Water	7/17/03-8/27/04	3	108.7	81.1	126	3
Prickly Pear Creek (from Helena WWTP Discharge Ditch to Lake Helena	MT411006_020	M09PKPRC02	Land and Water	7/17/03-9/24/04	6	112.47	33.5	332	4
Spring Creek (from Corbin Cr to the mouth)	MT41006_080	M09SPRGC01	Land and Water	7/14/03-9/24/04	6	8.87	2.20	23.2	0

Table 5. Nitrite and Nitrate as N									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean (mg/L)	Min (mg/L)	Max (mg/L)	# of Exceedances
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC01	Land and Water	7/15/03-8/11/03	2	0.035	0.02	0.05	1
		M09CLNCC03	Land and Water	7/15/03-8/11/03	2	0.18	0.14	0.22	2
		M09CLNCC04	Land and Water	7/16/03-8/12/03	2	0.025	0.02	0.03	0
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	M09WSNFC01	Land and Water	7/15/03-8/12/03	1		0.05		1
		M09WSNFC02	Land and Water	7/15/03-9/24/04	4	<0.06	<0.10	0.11	2
Prickly Pear Creek (from highway 433 crossing to Helena WWTP discharge)	MT411006_030	M09PKPRC05	Land and Water	7/17/03-8/27/04	3	<0.09	<0.01	0.20	2
		M09PKPRC01	Land and Water	7/17/03-8/27/04	3	0.52	0.52	0.66	3
Prickly Pear Creek (from Helena WWTP Discharge Ditch to Lake Helena	MT411006_020	M09PKPRC02	Land and Water	7/17/03-9/24/04	6	1.54	0.99	2.21	6
Spring Creek (from Corbin Cr to the mouth)	MT41006_080	M09SPRGC01	Land and Water	7/14/03-9/24/04	6	<0.137	<0.01	0.39	4

Table 6. Total Ammonia									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean Total Ammonia (mg/L)	Min Total Ammonia (Mg/L)	Max Total Ammonia (mg/L)	# of Exceedances
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC01	Land and Water	7/15/03-8/11/03	2	0.015	0.01	0.02	0
		M09CLNCC03	Land and Water	7/15/03-8/11/03	2	0.075	0.14	0.22	0
		M09CLNCC04	Land and Water	7/16/03-8/12/03	2	<0.01	<0.01	<0.01	0
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	M09WSNFC01	Land and Water	7/15/03-8/12/03	1	0.01	0.01		0
		M09WSNFC02	Land and Water	7/15/03-9/24/04	4	<0.01	<0.01	0.01	0
Prickly Pear Creek (from highway 433 crossing to Helena WWTP discharge)	MT411006_030	M09PKPRC05	Land and Water	7/17/03-8/27/04	3	0.013	0.01	0.02	0
		M09PKPRC01	Land and Water	7/17/03-8/27/04	3	0.030	0.02	0.04	0
Prickly Pear Creek (from Helena WWTP Discharge Ditch to Lake Helena	MT411006_020	M09PKPRC02	Land and Water	7/17/03-8/24/04	6	<0.033	<0.01	0.12	0
Spring Creek (from Corbin Cr to the mouth)	MT41006_080	M09SPRGC01	Land and Water	7/14/03-9/24/04	6	<0.032	<0.01	0.12	0

Table 7. Soluble Reactive Phosphorus									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean SRP (mg/L)	Min SRP (Mg/L)	Max SRP (mg/L)	# of Exceedances
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC01	Land and Water	7/15/03-8/11/03	2	0.0105	0.010	0.011	0
		M09CLNCC03	Land and Water	7/15/03-8/11/03	2	0.0055	0.004	0.007	0
		M09CLNCC04	Land and Water	7/16/03-8/12/03	2	0.0045	0.004	0.005	0
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	M09WSNFC01	Land and Water	7/15/03-8/12/03	1		0.028		1
		M09WSNFC02	Land and Water	7/15/03-9/24/04	4	0.021	0.014	0.027	4
Prickly Pear Creek (from highway 433 crossing to Helena WWTP discharge)	MT411006_030	M09PKPRC05	Land and Water	7/17/03-8/27/04	3	0 011	0.009	0.013	1
		M09PKPRC01	Land and Water	7/17/03-8/27/04	3	0.016	0.007	0.030	1
Prickly Pear Creek (from Helena WWTP Discharge Ditch to Lake Helena	MT411006_020	M09PKPRC02	Land and Water	7/17/03-9/24/04	6	0.45	0.281	0.598	6
Spring Creek (from Corbin Cr to the mouth)	MT41006_080	M09SPRGC01	Land and Water	7/14/03-9/24/04	6	0.010	0.003	0.026	2

Table 8. Total Suspended Solids									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean TSS (mg/L)	Min TSS (Mg/L)	Max TSS (mg/L)	# of Exceedances
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC01	Land and Water	7/15/03-8/11/03	2	5.59	1.68	9.5	0
		M09CLNCC03	Land and Water	7/15/03-8/11/03	2	<1.55	<1.00	2.10	0
		M09CLNCC04	Land and Water	7/16/03-8/12/03	2	1.94	1.91	1.97	0
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	M09WSNFC01	Land and Water	7/15/03-8/12/03	1		3.58		0
		M09WSNFC02	Land and Water	7/15/03-9/24/04	4	2.32	1.15	4.35	0
Prickly Pear Creek (from highway 433 crossing to Helena WWTP discharge)	MT411006_030	M09PKPRC05	Land and Water	7/17/03-8/27/04	3	2.12	1.57	3.11	0
		M09PKPRC01	Land and Water	7/17/03-8/27/04	3	3.06	1.49	5.73	0
Prickly Pear Creek (from Helena WWTP Discharge Ditch to Lake Helena	MT411006_020	M09PKPRC02	Land and Water	7/17/03-9/24/04	6	12.96	3.54	44	1
Spring Creek (from Corbin Cr to the mouth)	MT41006_080	M09SPRGC01	Land and Water	7/14/03-9/24/04	6	<22.01	<1.0	84	2

Water Chemistry Data for Lake Helena

Table 9. Total Nitrogen									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean TN (mg/L)	Min TN (mg/L)	Max TN (mg/L)	# of Exceedances
Lake Helena	MT411007 _120	M09LHLNN01	DEQ	8/9/02	1	1.48			**1**
		M09LHLNW01	DEQ	8/9/02	1	1.37			**1**
		M09LHLNE01	DEQ	8/9/02	1	1.50			**1**
		M09LHLNE01	Land and Water	6/26-8/29/03	2	0.82	0.65	0.99	**2**
		M09LHLNS01	DEQ	8/9/02	1	1.56			**1**
		Inflow	PPL	1/21/03	1	0.942			**1**
		M09LHLNI01 (inflow)	Land and Water	6/26-8/29/03	2	0.915	0.87	0.96	**2**
		Outflow	PPL	1/21/03	1	0.546			**1**
		M09LHLN001 (outlet)	Land and Water	6/26/-8/29/03	2	0.87	0.8	0.94	**2**
		M09LHLNC01	Land and Water	6/26/-8/29/03	2	0.85	0.71	0.99	**2**

Table 10. Total Phosphorus									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean TP (mg/L)	Min TP (mg/L)	Max TP (mg/L)	# of Exceedances
Lake Helena	MT411007_120	M09LHLNN01	DEQ	8/9/02	1	0.174			**1**
		M09LHLNW01	DEQ	8/9/02	1	0.140			**1**
		M09LHLNE01	DEQ	8/9/02	1	0.154			**1**
		M09LHLNE01	Land and Water	6/26/-8/29/03	2	0.221	0.064	0.377	**2**
		M09LHLNS01	DEQ	8/9/02	1	0.151			**1**
		Inflow	PPL	1/21/03	1	0.12			**1**
		M09LHLNI01 (inlet)	Land and Water	6/26/-8/29/03	2	0.162	0.019	0.305	**2**
		Outflow	PPL	1/21/03	1	0.10			**1**
		M09LHLN001 (outlet)	Land and Water	6/26/-8/29/03	2	0.218	0.080	0.355	**2**
		M09LHLNC01	Land and Water	6/26/-8/29/03	2	0.234	0.091	0.377	**2**

Supplemental Indicators for Lake Helena

Table 11. Total Nitrite and Nitrate Nitrogen									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean N (mg/L)	Min N (mg/L)	Max N (mg/L)	# of Exceedances
Lake Helena	MT411007_120	M09LHLNE01	Land and Water	6/26-8/29/03	2	0.04	0.02	0.06	**1**
		M09LHLNI01 (inflow)	Land and Water	6/26-8/29/03	2	0.18	0.01	0.35	**1**
		M09LHLN001 (outlet)	Land and Water	6/26/-8/29/03	2	0.04	0.02	0.06	**1**
		M09LHLNC01	Land and Water	6/26/-8/29/03	2	0.045	0.02	0.07	**1**

Table 12. Total Ammonia Nitrogen									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean (mg/L)	Min (mg/L)	Max (mg/L)	# of Exceedances
Lake Helena	MT411007_120	M09LHLNE01	Land and Water	6/26/-8/29/03	2	0.05	0.04	0.06	**0**
		M09LHLNI01 (inlet)	Land and Water	6/26/-8/29/03	1		0.14		**0**
		M09LHLN001 (outlet)	Land and Water	6/26/-8/29/03	2	0.08	0.07	0.09	**0**
		M09LHLNC01	Land and Water	6/26/-8/29/03	2	0.045	0.04	0.05	**0**

Table 13. Chlorophyll *a*									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Samples	Mean Clor a (mg/L)	Min Clor a (mg/L)	Max Chlor a (mg/L)	# of Exceedances
Lake Helena	MT411007_120	M09LHLNN01	DEQ	8/9/02	1	0.114			**1**
		M09LHLNW01	DEQ	8/9/02	1	0.057			**1**
		M09LHLNE01	DEQ	8/9/02	1	0.093			**1**
		M09LHLNE01	Land and Water	6/26/-8/29/03	2	<0.11	<0.01	0.012	**1**
		M09LHLNS01	DEQ	8/9/02	1	0.095			**1**
		M09LHLNI01 (inlet)	Land and Water	6/26/-8/29/03	2	<0.012	<0.01	0.014	**1**
		M09LHLN001 (outlet)	Land and Water	6/26/-8/29/03	2	<0.018	<0.01	0.026	**1**
		M09LHLNC01	Land and Water	6/26/-8/29/03	2	<0.016	<0.01	0.022	**1**

Table 14. Temperature Readings									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Readings	Temperature Readings	Min Temperature (F)	Max Temperature (F)	# of Exceedances
Lake Helena	MT41I007_120	M09LHLNE01	DEQ/Land and Water	8/9/02-8/29/03	18	67-56 F	56	67	0
		M09LHLNC01	DEQ/Land and Water	7/2/02-8/29/03	49	56-76F	56	76	**10**
		Station #3	DEQ	7/2/02-8/23/03	51	57-72 F	57	72	**12**
		M09LHLNT01	DEQ	7/2/02-8/29/03	24	57-75 F	57	75	**6**
		M09LHLNI01 (inlet)	Land and Water	6/26/-8/29/03	2	67-63	67	63	0
		M09LHLN001 (outlet)	Land and Water	6/26/-8/29/03	2	66-61	66	61	0
		M09LHLNS01	DEQ	8/9/02	4	61	61	61	0
		M09LHLNN01	DEQ	8/9/02	4	62-61	62	61	0
		M09LHLNW01	DEQ	8/9/02	3	58	58	58	0
		M09LHLNL01 (station #1)	FWP	7/2/02-8/29/03	36	56-78	56	78	4
		Temperature logger	FWP	6/10/03-1/24/04	Once per hour from June 2003 to January 2004	31.88-81.44	31.88	81.84	**1682** logger was placed 3 feet below the surface, where depth was 6 feet deep in the mid column

Table 15. Secchi Disc Readings							
Segment Name	Listed Segment	Station Number	Agency	Period of Record	# of Readings	Secchi disc Readings (ft)	Notes
Lake Helena	MT41I07_120	M09LHLNI01 (inlet)	FWP	6/26/03-8/29/03	2	1.10-0.90	Secchi depth taken by FWP technician, approx water depth 4 ft from FWP depth reader
		M09LHLNC01	FWP	6/26/03-8/29/03	2	0.95-3.5	Secchi depth taken by FWP technician, approx water depth 7 ft from FWP depth reader
		M09LHLNE01	FWP	6/26/03-8/29/03	2	0.50-1.70	Secchi depth taken by FWP technician, approx water depth 2.5 ft from FWP depth reader
		M09LHLN001 (outlet)	FWP	6/26/03-8/29/03	2	1.0-1.10	Secchi depth taken by FWP technician, approx water depth 10-12 ft from FWP depth reader

Biological Data for Streams

Pre-2003 Biological Data for Stream

Table 16. Pre-2003 Biological Information

Segment Name	Listed Segment	Station Number	Assessment Type	Period of Record	Comments
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC01 headwaters	DEQ stream reach assessment form	8/1/01	Visual assessment of aquatic plant growth, predominantly brown algae, turbidity clear
			DEQ macroinvertebrate survey	8/1/2001	-slight impairment and partial support of designated uses -five individuals in a single taxon comprised the mayfly fauna at **Clancy Creek**, casting suspicion on the low biotic index value (2.44) for this site -one species of stonefly comprised 72% of the organisms of this sample **-such a bloom of this animal suggests that the site on Clancy Creek may have a large loading of organic debris such as leaves, grass blades or twigs** **-water quality may be impaired by nutrients assoc with organic material, resulting in depression of mayfly richness** **-Clancy Creek may have a superabundance of large organic debris, some indication of elevated nutrient concentration is suggested**
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	-sample site was located at 46 25'14"N, 111 56'20"W	DEQ macroinvertebrate survey	07/21/2001	single aquatic invertebrate sample taken near the mouth of North Fork Warm Springs Creek, just above the USFS boundary -bioassessment results indicate that this site on North Fork Warm Springs Creek fully supports designated uses and sustains a benthic assemblage with essentially unimpaired biotic health -conclusion is that taxonomic and functional composition of the sample taken at North Fork Warm Springs Creek suggest that habitat and water quality were essentially undisturbed -Hilsenhoff Biotic Index was 4.48 , meaning water quality was very good, possible slight organic pollution
		- near the mouth of the North Fork of Warm Springs Creek latitude 46 25 14 N, Longitude 111,56, 20 W	DEQ periphyton survey	07/24/2000	-a composite periphyton sample was collected from natural substrates -low diatom species richness together with a low pollution index, a high sedimentation index, and a relatively large percentage of tetralogical diatom frustules, all indicate moderate impairment and partial support of aquatic life uses **-probable causes of this impairment are contamination of heavy metals, and excessive sedimentation and organic loading**
		-North Fork Warm Springs from USFS boundary to 100 yards upstream	DEQ stream reach assessment form	07/24/2000	-aquatic plant growth found in small patches or along the channel edges -mosses, micro algae mainly (95%), brownish green -turbidity was clear
Sevenmile Creek (from Lake Helena to Hauser Lake)	MT411006_160	-Sevenmile Creek, 8/1/01 near confluence with Tenmile Cr	DEQ macroinvertebrate survey	8/1/01	-69% of creatures in the sample were tolerant taxa, water quality impairment may be the result of nutrient and/or organic inputs and or water temperatures **-Sevenmile Cr may be impaired by nutrients and/or elevated water temps**
			DEQ macroinvertebrate survey	1997	-impairment ratings for the site sampled on Sevemile Creek was 0.72 and 0.56 indicating moderate water quality impairment and violation of established standards - chironomids accounted for the largest percent of dipterans found in Sevenmile Creek at 35.3%--- the relative abundance of chironomids relative to other diptera is indicative of eutrophication -Nitrogen (NO3-N) and phosphorus (total and dissolved as ortho-P) were substantially greater in Sevenmile Cr (SMC1) than the sites in Tenmile Cr -water quality and habitat conditions are influencing the macroinvertebrate communities in Sevenmile Cr -nutrient enrichment is evident in Sevenmile Cr, the abundance and composition of the macroinvertebrate community in Sevenmile Cr is partially a response to increased nutrients working in concert with decreased concentrations of heavy metals -id sevenmile creek as a source of eutrophication

Segment Name	Listed Segment	Station Number	Assessment Type	Period of Record	Comments
Sevenmile Creek (from Lake Helena to Hauser Lake)	MT411006_160		-DEQ periphyton assessment	July 15-16 1997	-sevenmile had poor biological integrity, nutrient enrichment was a secondary cause of impairment -algal growth was heavy in sevenmile creek -diatoms and green algae dominated in sevenmile -this shift in taxonomic composition below sevenmile cr is compatible with measured downstream increases in nutrients etc. -sevenmile creek is a significant source of both algal nutrients and dissolved solids in tenmile -sevenmile creek also supported Prasiola, a green alga that indicates nutrient enrichment -some nutrient enrichment is indicated in sevenmile creek
		headwater	DEQ macroinvertebrate survey	8/1/2001	-slight impairment and partial support of designated uses -five individuals in a single taxon comprised the mayfly fauna at **Clancy Creek**, casting suspicion on the low biotic index value (2.44) for this site -one species of stonefly comprised 72% of the organisms of this sample **-such a bloom of this animal suggests that the site on Clancy Creek may have a large loading of organic debris such as leaves, grass blades or twigs** **-water quality may be impaired by nutrients assoc with organic material, resulting in depression of mayfly richness** **-Clancy Creek may have a superabundance of large organic debris, some indication of elevated nutrient concentration is suggested**
			DEQ macroinvertebrate survey	1997	-impairment ratings for the site sampled on Sevemile Creek was 0.72 and 0.56 indicating moderate water quality impairment and violation of established standards - chironomids accounted for the largest percent of dipterans found in Sevenmile Creek at 35.3%--- the relative abundance of chironomids relative to other diptera is indicative of eutrophication -Nitrogen (NO3-N) and phosphorus (total and dissolved as ortho-P) were substantially greater in Sevenmile Cr (SMC1) than the sites in Tenmile Cr -water quality and habitat conditions are influencing the macroinvertebrate communities in Sevenmile Cr -nutrient enrichment is evident in Sevenmile Cr, the abundance and composition of the macroinvertebrate community in Sevenmile Cr is partially a response to increased nutrients working in concert with decreased concentrations of heavy metals -id sevenmile creek as a source of eutrophication
Tenmile Creek (from the Helena WT plant to the mouth)	MT411006_143	-Tenmile Creek, 8/1/01, below at confluence with Seven mile creek (ten 1)	DEQ macroinvertebrate survey	8/1/01	-downstream Tenmile Site—moderate impairment of biotic health and partial support of uses -mildly elevated biotic index value (4.92) suggests that slight impairment of water quality possible at **Tenmile Creek**, 28% animals in sample were tolerant, large numbers of blackflies (Simulium) suggest that fine organic particles in suspension may be plentiful **-bioassessment score for lower Tenmile Cr—appears to exaggerate impairment, mild water quality degradation**
		(TMC2-BCG) (TMC3-WSB) (TMC4-GMD) (TMC5-SRE (PPC))	DEQ macropyte survey	1997	-impairment ratings for the sites sampled on Tenmile Creek were >0.75 indicating full support of water quality use and no violations of standards -percent of dipterans that belonged to the family Chironomidae was lowest at the upstream sites averaging less than 4%, chironomids accounted for the largest percent of dipterans found at the site downstream in Tenmile Creek (TMC4-GMD) at 15%--the relative abundance of chironomids relative to other diptera is indicative of eutrophication -organic/nutrient enrichment seems to be affecting overall biotic integrity on the lower reach of Tenmile Creek -abundance and composition of the macroinvertebrate community downstream in Tenmile Cr is partially a response to increased nutrients working in concert with decreased concs of heavily metals -water quality in Tenmile Cr is not impairing the biotic integrity of the macroinvertebrate community

Segment Name	Listed Segment	Station Number	Assessment Type	Period of Record	Comments
Tenmile Creek (from the Helena WT plant to the mouth)	MT411006_143		-DEQ periphyton assessment	July 15-16 1997	-five sites on lower tenmile cr -below Colorado Gulch had good biological integrity compared to least impaired reference streams in western MT -tenmile creek sites are Williams Street and Green Meadow Drive had fair biological integrity compared to least impacted reference streams in western MT—siltation and nutrient enrichment caused moderate impairment at these sites -tenmile Cr at Sierra rd had poor biological integrity, nutrient enrichment was a secondary cause of impairment -algal growth ranged from light at the water plant and the Williams street sites to heavy in sevenmile creek and at the green meadow drive site on tenmile cr -nitrogen fixing blue-green algae were common only at the lower two sites on tenmile—this may indicate increasing nitrogen deficiency downstream with respect to an increase in available P -some nutrient enrichment is indicated in sevenmile creek and at the two downstream sites on tenmile creek -tenmile creek shows evidence of nutrient enrichment as it leaves the mountains and crosses the Helena valley -pollution values increased downstream in tenmile creek to a low value at sierra rd -pollution index values for all of the sites fell below the range of values for least impaired reference streams in western mt, pollution index values for green meadow drive site and the sierra rd site indicated moderate impairment -colorado gulch had good biological integrity, with minor impairment, Williams st rated fair biological integrity with moderate impairment, downstream from sevenmile, the green meadow drive and sierra road sites rated fair and poor—siltation and pollution (organic matter and inorganic nuts) were co-limiting at the green meadow drive sites and siltation was the main limiting factor at the sierra road site
	M09TenMC01		DEQ stream reach assessment form	7/30/2001	-aquatic plant growth, upstream, in small patches or along channel edges, excellent types, possibly profuse growth due to nutrients from upstream golf course (200 yards upstream) -turbidity was rated as clear

New 2003 Biological Data for Streams

Table 17. 2003 Biological Information

Segment Name	Listed Segment	Station Number	Assessment Type	Period of Record	Comments
Spring Creek (from Corbin Creek to the mouth) PPC	MT411006_08 0	At same location as the water quality samples	Land and Water periphyton assessment	08/28/03	-diatom metrics indicate organic loading caused minor impairment to aquatic life uses in Spring Creek, minor impairment is likely due to organic loading among others (heavy metals and excessive sedimentation) -14 major diatom species from Spring Creek represent pollution tolerant classes 3,2,1 and are either sensitive to organic pollution, somewhat tolerant of organic pollution, or very tolerant of organic pollution **-three of the remaining 7 major diatom species in Spring Creek are very tolerant of organic pollution (pollution tolerance class 1) and the other 4 are somewhat tolerant of organic pollution** -In Spring Creek, most diatoms were autotrophs that can tolerate high levels of organics, ranging from oligotrophic to hyper-eutrophic
		At same location as the water quality samples	Land and Water macroinvertebrate survey	08/28/03	-Spring Creek near Jefferson City was moderately impaired **and did not support designated uses** -midges, other flies and tubificid worms dominated the aquatic invertebrate sample collected from Spring Creek at Jefferson City -biotic index high (5.86) compared to expectation for valley and foothills stream -abundance of worms suggests that nutrient enrichment may have resulted in hypoxic sediments
Prickly Pear Creek (from Highway 433 Crossing to Helena WWTP Discharge)	MT411006_03 0	Below East Helena	Land and Water periphyton assessment	08/28/03	-biological integrity good. Diatom metrics indicated only minor impairment from organic loading and full support of aquatic uses at this site. Full support of aquatic life uses. Other genera of green algae that are among those most tolerant of organic pollution were common to abundant. Good biological integrity and full support of aquatic life uses. ***Gomphonema parvulum* was the most abundant at this site, *Gomphonema clavatum* was the most abundant species. This species is somewhat tolerant of organic pollution. Two of the most abundant diatom species here are sensitive to organic pollution, and a third is somewhat tolerant.** The pollution index here indicated minor impairment and less organic loading that PPC site upstream at East Helena. Most diatoms were autotrophs that tolerate low levels of organic matter. **Most diatoms indicated eutrophic conditions.**
		Above Stansfield Lake			-biological integrity good). Biological integrity good. Diatom metrics indicated only minor impairment from organic loading and full support of aquatic uses at this site. Full support of aquatic life uses. Macrophytes present. **Other green algae were abundant here and indicate some organic enrichment. A diatom which is somewhat tolerant of organic pollution was the second most abundant species and another pollution tolerant diatom was the next most abundant.** Minor impairment and the lowest level of organic loading than any of the other study sites. Most diatoms tolerate a wide range of nutrient regimes.
		Below East Helena	Land and Water macroinvertebrate assessment	08/28/03	PPC moderately impaired at East Helena, partially supported designated uses. Conditions worsened. Biotic values highest in the study. Species suggest nutrient enrichment may further degrade water quality. Taxonomic composition suggests WQ impaired by nutrients.
		Above Stansfield Lake			Moderately impaired. Partially supported uses. Elevated biotic index could be associated with nutrient enrichment. Implies year round surface flow. Functional composition assemblage expected by filter feeders dominate, suggesting nutrient enrichment.
Prickly Pear Creek (from Helena WWTP discharge Ditch to Lake Helena	MT411006_02 0	Above Tenmile Creek	Land and Water periphyton assessment	08/28/03	-moderate impairment was recorded at PPC above Tenmile Creek. Primary cause was sedimentation, and secondary cause was excessive organic loading. Site was dominated by filamentous green algae and eutraphentic diatom species (taxa that tolerate nutrient enrichment. Full support of aquatic life uses. Diatoms extremely numerous. Macrophytes common. **Filamentous green algae indicated elevated nutrient concentrations. Only site with red algae—among genera of freshwater red algae—*Audoninella*** is the **most tolerant of organic pollution**. Most tolerant diatom is somewhat tolerant of organic pollution. The next three most abundant species above Tenmile Creek are also tolerant of organic loading. **Most diatoms were autotrophs that can tolerate high levels of organics.** Diatoms can use organic matter as a source of N. **Most diatoms indicated eutrophic conditions.**
		Above Tenmile Creek	Land and Water macroinvertebrate assessment	08/28/03	This site was moderately impaired, partially supported uses. Nutrient enrichment suggested by assemblage. Water quality continued to be degraded downstream above Tenmile. Elevated biotic index. Nutrient enrichment evidenced by prolific filter feeders and abundance of tolerant animals, including mayflies, and microcaddisfly which is commonly assoc. with filamentous algae.

2002-2003 Field Data for Streams and Lake Helena

Table 18. 2003 Field Data for Streams										
Segment Name	Listed Segment	Station Number	Agency	Period of Record	Temp (C/F)	pH	SC (us/cm)	DO (mg/L)	Flow (cfs)	Turbidity
Clancy Creek (from headwaters to the mouth)	MT411006_120	DEQM09CLNCC01	Land and Water	7/15/03-8/11/03	19.2-21.3 (67-70)	6.86-8.1	192-230	7.3-8.5	0.1-0.61	None, clear
		M09CLNCC03	Land and Water	7/15/03-8/11/03	11.7-15.2 (53-59)	6.7-7.9	205-235	9-10.1	0.75-1.4	None, clear
		M09CLNCC04	Land and Water	7/16/03-8/11/03	14.2-15.1 (58-59)	8.3-8.4	264-289	8.6-10.6	0.62-1.1	Clear, none
North Fork Warm Springs Creek (headwaters to mouth)	MT411006_180	M09WSNFC01	Land and Water	7/15/03	17.7 (64)	7.1	188	9.4	0.01	Clear, none
		M09WSNFRC02	Land and Water	7/17/03-9/24/04	8-15.8 (46-60)	7-8.0	185-211	7.8-10.2	0.003-0.16	Clear, none
Prickly Pear Creek (from highway 433 crossing to Helena WWTP discharge)	MT411006_030	M09PKPRC01	Land and Water	7/17/03-8/27/04	11.9.2-19 (53-66)	7.8-8.15	292-420	8.2-13.8	1.3-8.2	None, clear
		M09PKPRC05	Land and Water	7/17/03-8/27/04	14-24 (58-76)	8.1-9.2	233-322	8.2-9.2	0.54-22.1	Clear to slight
		M09PKPRC03	Land and Water	7/17/03-8/12/03	**DRY**	**DRY**	**DRY**	**DRY**	**DRY**	**DRY**
Prickly Pear Creek (from Helena WWTP Discharge Ditch to Lake Helena	MT411006_020	M09PKPRC02	Land and Water	7/17/03-9/24/04	9.4-23 (48.92-73)	7.7-9	424-623	7.7-14.5	8.4-22.1	Clear to slightly turbid
Spring Creek (from Corbin Cr to the mouth)	MT41006_080	M09SPRGC01	Land and Water	7/13/03-9/24/04	7.5-23.7 (45.5-75)	7.7-8.3	666-783	6.1-9.9	0.1-0.84	Clear to slight

Table 19. Field Data for Lake Helena									
Segment Name	Listed Segment	Station Number	Agency	Period of Record	Temp (C/F)	pH	SC (us/cm)	DO (mg/L)	Turbidity
Lake Helena	MT411007_120	M09LHLNO01	Land and Water	6/26/03-8/28/03	16.1-19 (61-66)	8.2	267-461	5.7-10.5	none
		M09LHLNI01	Land and Water	7/15/03-8/29/03	17.1-19.2 (63-67)	8.2	324-453	5.4-10.8	none
		M09LHLNE01	Land and Water	6/26/03-8/29/03	16.7-19.3 (62-67)	8.1-8.6	279-460	5.1-11.7	none
		M09LHLNC01	Land and Water and Fish, Wildlife and Parks	6/26/02-8/29/03	13.6-24.7 (56-76)	7.59-8.74	271-465	1.8-11.5	none
		Lake Helena #1 (M09LHLNL01)	Fish, Wildlife and Parks	7/2/02-8/29/03	13.14-25.5 (56-78)	7.73-9.0	274-369	2.65-10.31 (33-119%)	No readings were taken
		Lake Helena #3	Fish, Wildlife and Parks	7/2/02-8/29/03	13.64-22.11 (56.55-71.8)	7.58-8.66	267-365	2.13-9.79 (27-106.6%)	No readings were taken
		M09LHLNT01	Fish, Wildlife and Parks	7/2/02-8/29/03	13.69-24.11 (56.6-75.11)	7.93-9.31	324.3-376.8	3.01-10.74 (40.5-132.7%)	No readings were taken

Diel Dissolved Oxygen Information for Surveyed Streams

Table 20. 24 Hour DO Run August 7th and 8th, 2003

SITE: M09PKPRC01 Prickly Pear above Stansfield Lake (Olsen Rd) at bridge crossing			
Time	**DO (mg/L)**	**Temp (C)**	**Comments**
1015	7.8	12.5	Flow estimated at less than 1 cfs
1215	8.8	15.2	groundwater influence evident
1415	9.1	18.2	Trout fry present in abundance
1615	8.9	19.9	Macrophytes, filamentous green algae present
1815	8.2	20.4	
2023	6.4	18.7	
2221	5.1	17.0	D.O. readings stable
0015	4.6	15.2	D.O. readings stable, trout observed
0215	4.7	13.8	9 to 10" trout observed by flashlight
0415	5.0	12.7	
0615	5.3	12.0	Creek is dry at Canyon Ferry Road
0814	6.0	11.8	and barely running at York Rd.
1010	7.5	13.0	Flow at Olsen Rd is mostly groundwater/springs.

SITE: M09PKPRC02 Prickly Pear above Tenmile Creek at Sierra Rd bridge.			
Time	**DO (mg/L)**	**Temp (C)**	**Comments**
1030	13.7	15.1	Slightly tannin stained water. Flow estimated at 7 cfs.
1230	17.9	18.3	Heavy filamentous algae and diatom algae present.
1433	19.1	22.2	
1630	16.1	23.1	Lots of minnows present, no trout observed.
1830	13.7	23.2	
2037	7.7	20.9	Flow appears to be > 7 cfs now.
2234	5.4	18.7	Stable D.O. readings.
0030	4.9	17.7	Stable D.O. readings.
0230	4.9	16.7	
0430	5.0	15.8	Tannin stained water, lots of periphyton.

0630	5.3	15.1	
0825	8.5	15.0	Flow estimated at 7 to 8 cfs.
1025	14.0	16.6	

Weather clear, sunny, warm at start of survey. High temp of 93 (F) forecast.

SITE: M09PKPRC05 Prickly Pear below East Helena private ranch access road bridge just below Wylie Drive			
Time	**DO (mg/L)**	**Temp (C)**	**Comments**
1000	9.2	18.0	Flow estimated at 3 cfs
1200	9.3	21.2	Heavy filamentous green algae in upstream riffle
1400	9.0	24.8	Thunderheads building to the west. Breezy.
1600	8.6	25.6	Air temp at 3:45 pm was 89(F), increasing clouds.
1800	8.8	25.4	Hot and breezy, clouds dissipating.
2000	7.4	23.3	Readings not stable. Hazy, high clouds.
2200	6.8	21.7	Readings not stable. Hazy, high clouds.
0000	6.8	20.2	Readings stable.
0200	7.2	19.0	Readings stable.
0400	7.3	18.1	
0600	7.5	17.4	Dawn. Light enough to see without light.
0800	8.6	17.1	Cloudless sky, light breeze.
0955	9.9	18.4	

SITE: M09WSNFC02 North Fork Warm Springs abv Middle Fork			
Time	**DO (mg/L)**	**Temp (C)**	**Comments**
1020	7.8	13.2	Low flow, less than 1 cfs.
1220	7.5	14.2	Very little algae or aquatic plant growth.
1420	7.0	16.8	Some mosses about bankfull.
1620	6.6	17.4	
1820	6.0	16.2	
2020	6.2	15.5	
2220	6.4	14.8	
0020	6.4	14.3	

0220	6.7	13.8	
0420	6.7	13.4	
0620	7.4	13.0	
0820	7.1	12.8	
1020	7.7	13.2	

SITE: M09WSNFC01 North Fork Warm Springs @ mouth			
Time	**DO (mg/L)**	**Temp (C)**	**Comments**
1030	7.8	14.4	Just a trickle of flow, even less than upper site, walked about 100 feet upstream of sample site.
1230	7.5	15.7	
1430	6.8	17.9	Had to move upstream about 10 feet, flow is drying out.
1630	6.4	18.6	
1835	6.6	17.2	Probe error, had to wait for stabilization, moved upstream about 3 feet.
2030	6.7	16.3	
2230	6.8	15.3	
0030	6.4	14.6	
0230	6.9	13.9	
0430	6.9	13.4	
0630	7.2	13.0	
0830	6.8	12.9	
1030	7.8	14.4	

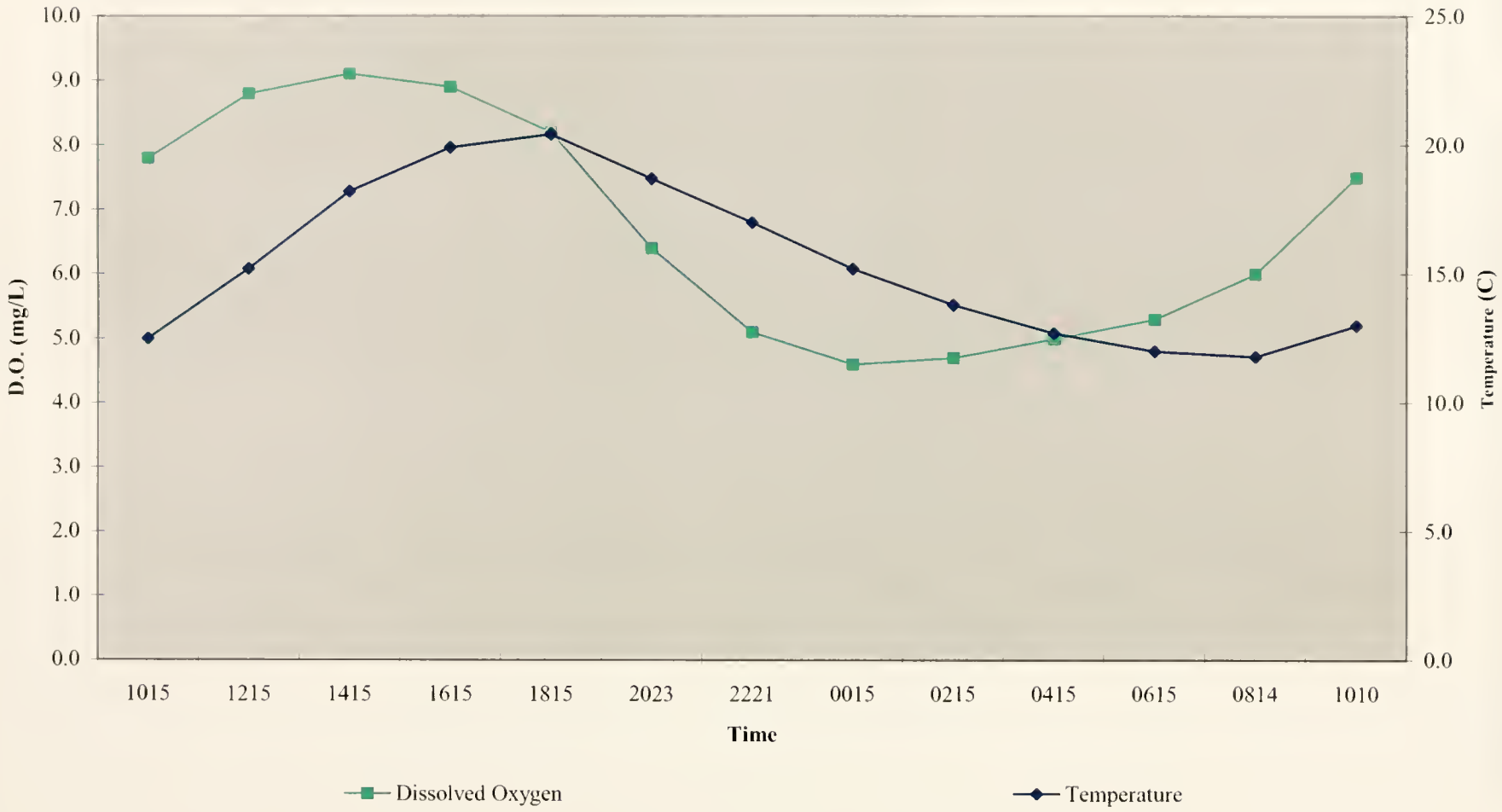
SITE: M09CLNCC04 Clancy Creek @ Clancy			
Time	**DO (mg/L)**	**Temp (C)**	**Comments**
1000	9.0	12.9	Clear, cool water, good flow (about 3 cfs), algal growth present but not excessive.
1200	8.3	15.5	Warming up, sunny.
1400	7.8	18.7	
1600	7.4	19.8	Increasing cloud cover, cooling a little.
1800	7.4	19.7	Clearing weather, still warm.

2000	7.4	18.4	
2200	7.3	16.7	Dark, cooling, slightly humid.
0000	7.7	15.1	
0200	8.3	13.8	Probe acting erratic.
0400	8.5	12.9	
0600	8.7	12.1	Daylight.
0800	8.6	11.8	
0100	9.1	13.2	

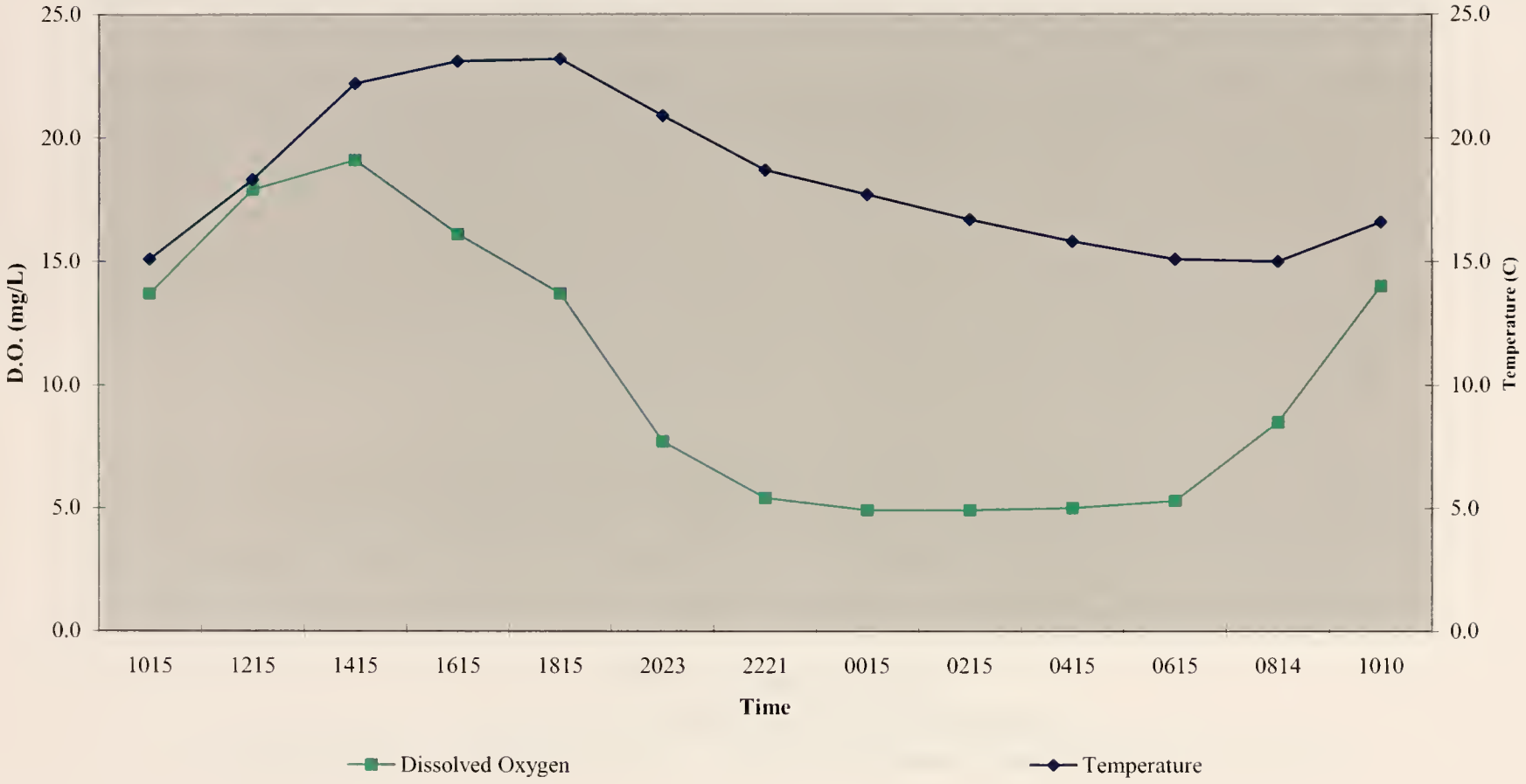
SITE: M09SPRGC01 Spring Creek @ Jefferson City			
Time	**DO (mg/L)**	**Temp (C)**	**Comments**
1103	8.7	12.5	Had to move way upstream for flow to just below mouth of Corbin Creek(still dry) 46 22' 50.3" and 112 03' 37.3".
1300	8.3	14.4	
1500	8.1	15.2	Storm clouds building in W, increasing winds.
1700	8.1	14.1	Thunder, clouds passing over, no rain.
1900	8.5	12.0	
2100	9.1	10.9	
2300	8.9	10.4	Mosses in stream growing along edges and browning out, algal growth present.
0100	9.0	9.9	
0300	9.4	9.6	
0500	9.2	9.3	
0700	9.0	9.1	
0900	9.2	9.9	
1100	8.9	12.1	

Dissolved Oxygen and Temperature Graphs

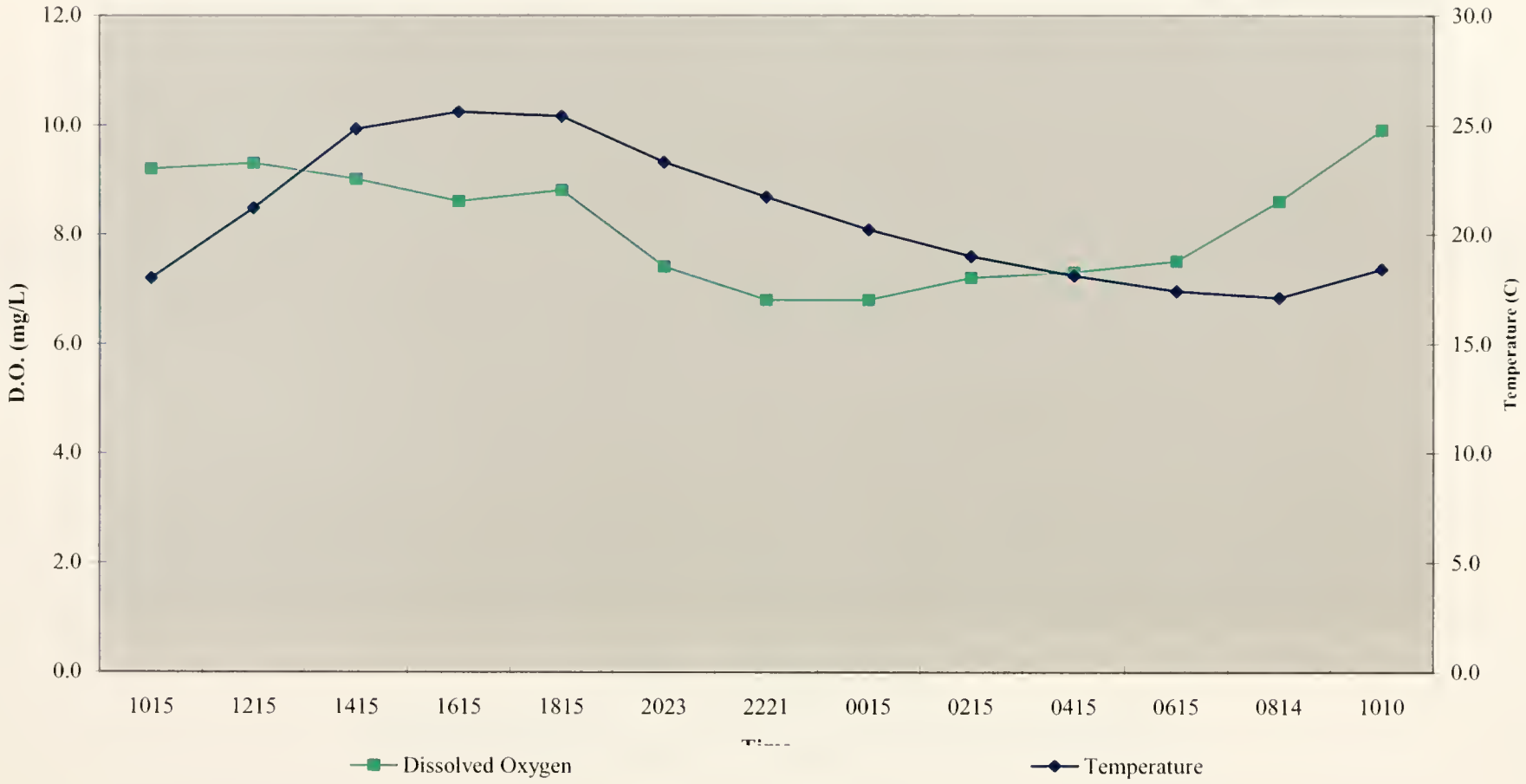
A. Diel Dissolved Oxygen Survey for Prickly Pear Above Stansfield Lake
August 7th and 8th, 2003



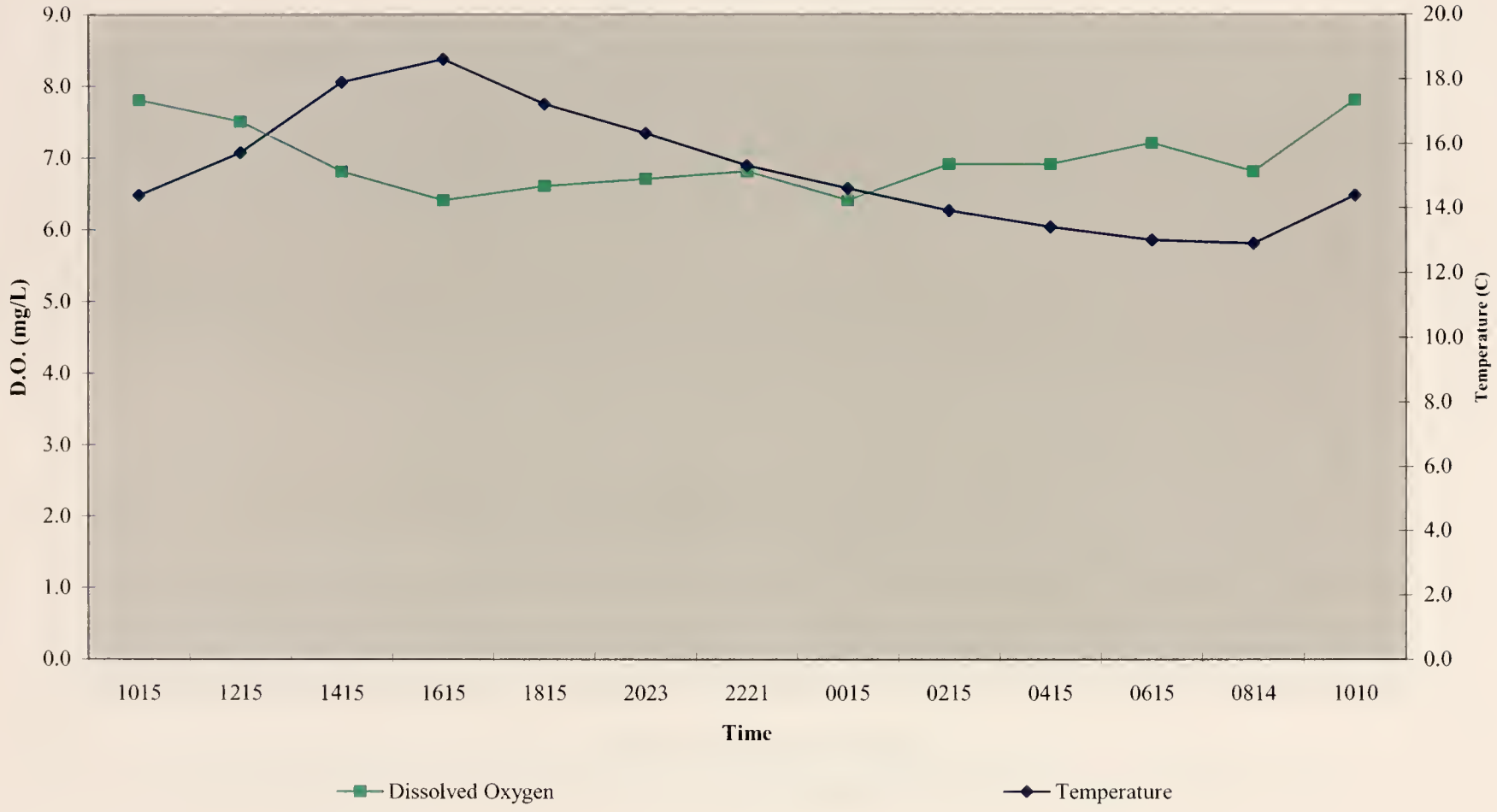
B. Diel Dissolved Oxygen Survey for
Prickly Pear Above Tenmile Creek @ Sierra Road Bridge
August 7th and 8th, 2003



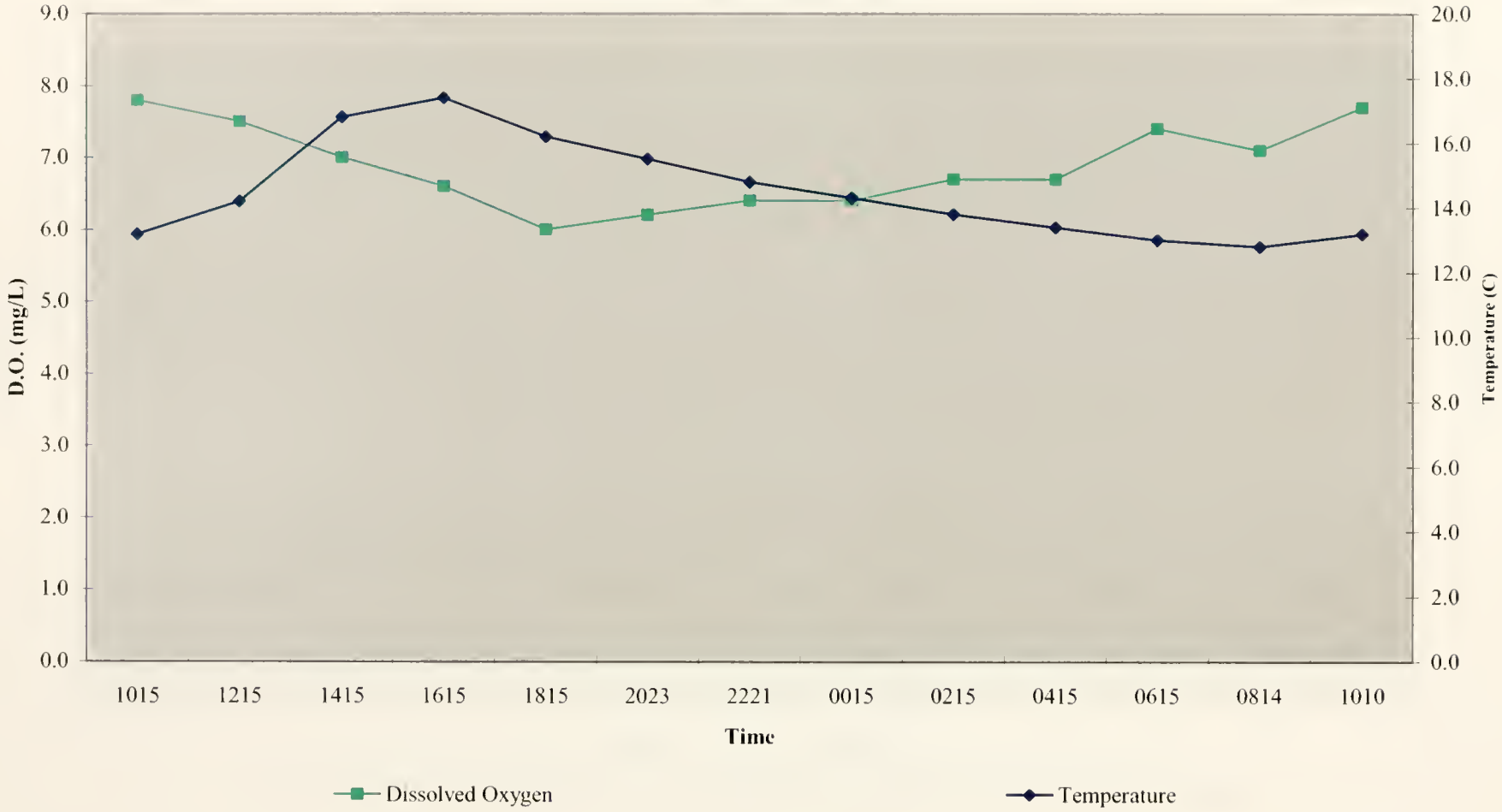
C. Diel Dissolved Oxygen Survey for Prickly Pear Below East Helena Private Ranch Access Road Bridge Just Below Wylie Drive August 7th and 8th, 2003



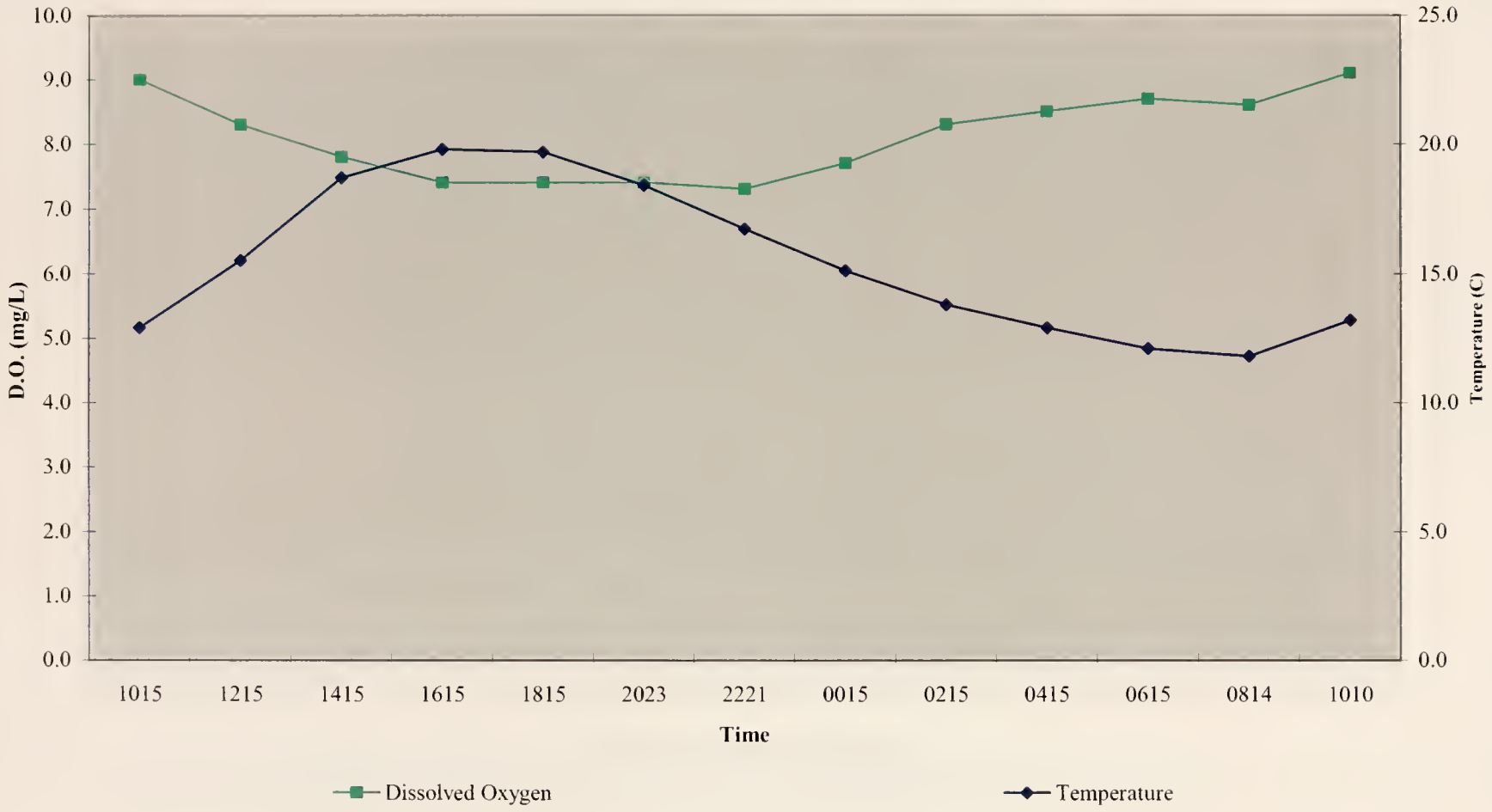
D. Diel Dissolved Oxygen Survey for North Fork Warm Springs @ Mouth
August 7th and 8th, 2003



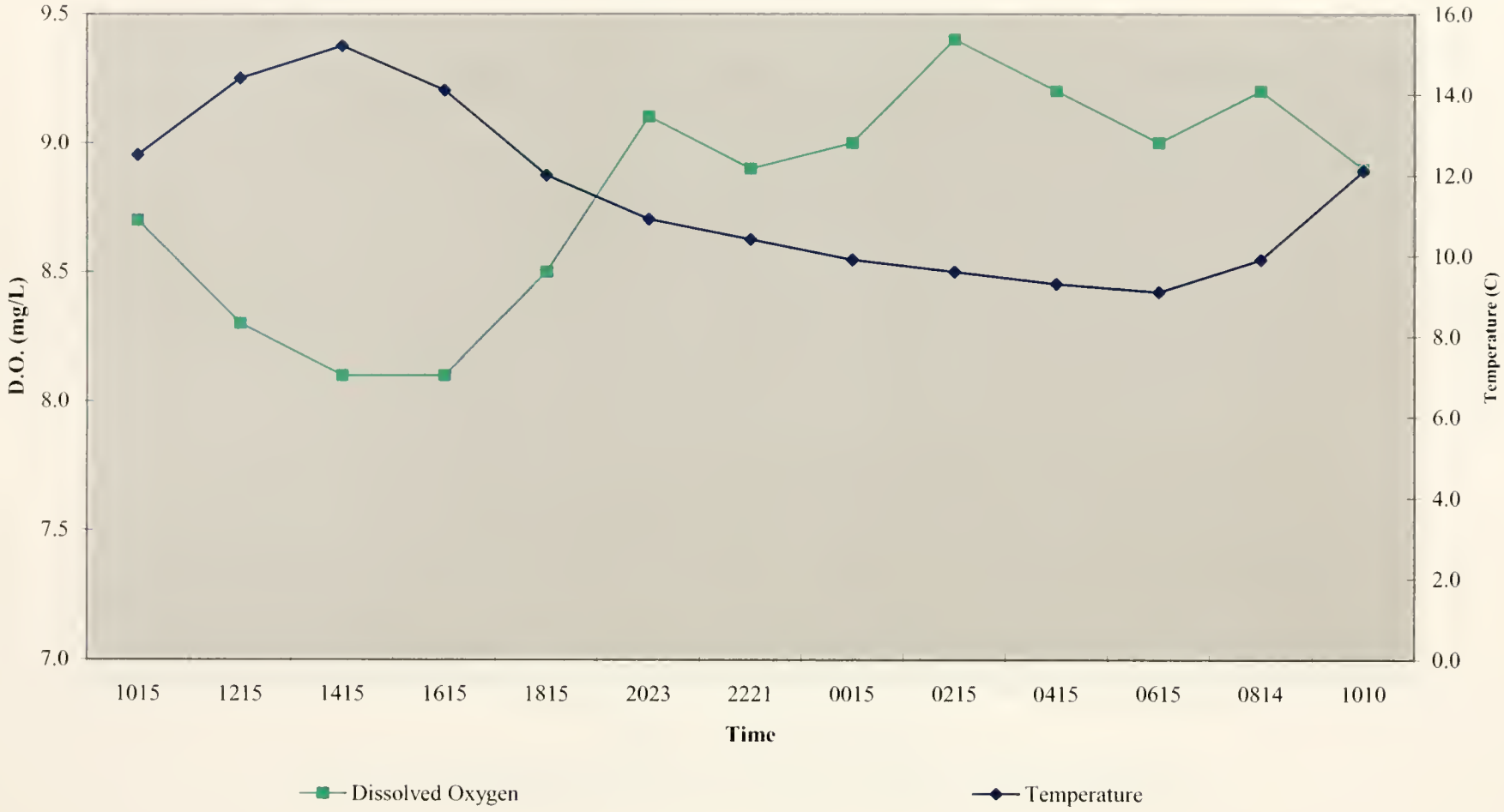
E. Diel Dissolved Oxygen Survey for North Fork Warm Springs Above Middle Fork
August 7th and 8th, 2003



F. Diel Dissolved Oxygen Survey for Clancy Creek @ Clancy
August 7th and 8th, 2003



G. Diel Dissolved Oxygen Survey for Spring Creek @ Jefferson City
August 7th and 8th, 2003



Reference Stream and Lake Helena Trophic State Information

Table 21. Reference Stream Information

Nutrient Ecoregion	Reference Stream	TKN Values mg/L	TN Values (calculated) mg/L	Nitrite plus Nitrate mg/L	Total Phosphorus Values (mg/L)	Total Ammonia (mg/L)	Soluble Reactive Phosphorus (mg/L)	Sample Date	Flow (cfs)	Periphyton chlor a mg/m2
2003 Reference Stream Information										
Northern Rockies	Dutchman Creek	<0.10	<0.11	<0.01	0.008	<0.01	0.006	09/04/03	0.64	49.1
Northern Rockies	South Fork Warm Springs Creek	<0.10	<0.11	<0.01	0.005	<0.01	0.001	09/04/03	0.81	60.6
Montana Valley Foothill and Prairies	McClellan Creek	<0.10	<0.11	<0.01	0.008	<0.01	0.005	09/04/03	4.0	17.9
Northern Rockies	Shingle Mill	<0.10	<0.11	<0.01	0.007	0.01	0.007	09/05/03	0.43	32.7
Northern Rockies	Walker Creek	<0.10	<0.11	<0.01	0.015	0.01	0.011	09/05/03	0.01	11.2
Northern Rockies	Moose Creek	<0.10	<0.11	<0.01	0.017	<0.01	0.009	09/08/03	0.1	108
										mean=46.58
2001 Reference Stream Information										
Montana Valley Foothill and Prairies	McClellan Cr	0.3	0.3	<.01	0.025	no data	no data	8/8/2001	no flow measurements taken	38
	McClellan Cr			0.04		no data	no data	8/8/2001		7
Montana Valley Foothill and Prairies	Skelly Gulch Cr	0.3	0.3	<.01	0.026	no data	no data	7/31/2001	no flow measurements taken	7.6
northern Rockies	Monitor Cr	0.3	0.3	0.02	0.027	no data	no data	7/31/2001	no flow measurements taken	N/A
northern Rockies	MF Warm Springs Cr	0.2	0.2	0.04	0.022	no data	no data	8/7/2001	no flow measurements taken	13.8
northern Rockies	Warm springs Cr	0.2	0.2	<.01	0.023	no data	no data	8/7/2001	no flow measurements taken	22
										mean=17.68
										overall mean=36.9

Table 22. Estimates of Lake Helena's Trophic State Index (TSI) from Montana DEQ

Comparison lakes are from the Northern Rockies (15), Middle Rockies (17) and (16) ecoregions.

BASIC DATA:	**Maximum depth (m)**	2.4							
	Surface Area (m^2)	8387688.5							
	Relative Depth:	0.07							
	Approximate mean depth* (m):	0.80	***(may be as high as 1.5)**						
	Secchi Depth (2003) (m) :	0.41							
	Mean Chl a (n=12, 2003-2004) µg/L:	39.00							
		TSI-TP	*TSI-TN*	*TSI-Secchi*	*TSI-Chl a*		Carlson's Equations for TP, TN		
	Current Carlson TSI estimates:	**79.0**	**54.9**	**72.8**	**66.5**		TP Equation	TN Equation	
Estimates of what Lake Helena should be, based on its characteristics						slope	y intrcpt	slope	y intrcpt
Source	**Carlson TSI**	**TP (µg/L)**	**TN (mg/L)**						
*From Chl a regress for **mean depth** (all lakes):*	47.1	**19.70**	**0.60**		**High Values**	14.42	4.15	14.43	54.45
From TP regression (all lakes):	51.9	**27.36**	**0.84**			14.42	4.15	14.43	54.45
From Chl a regression (all lakes):	47.6	**20.40**	**0.62**			14.42	4.15	14.43	54.45
Mean Carlson TSI_{TP} of lakes with Zr <1.0:	42.8	**14.59**	**0.45**			14.42	4.15	14.43	54.45
Median Carlson TSI_{TP} of lakes with Zr <1.0:	38.3	**10.68**	**0.33**		**Means, Medians**	14.42	4.15	14.43	54.45
Mean Carlson $TSI_{Chl\ a}$ of lakes with Zr <1.0:	38.8	**11.06**	**0.34**			14.42	4.15	14.43	54.45
Median Carlson $TSI_{Chl\ a}$ of lakes with Zr <1.0:	37.5	**10.10**	**0.31**			14.42	4.15	14.43	54.45
25% Carlson TSI_{TP} of lakes with Zr <1.0:	37.5	**10.10**	**0.31**			14.42	4.15	14.43	54.45
25% Carlson $TSI_{Chl\ a}$ of lakes with Zr <1.0:	34.8	**8.38**	**0.26**		**25 Percentiles**	14.42	4.15	14.43	54.45
EPA recommended criteria, composite nutrient ecoregion II:	35.4	**8.75**	**0.10**						
EPA recommended criteria, Lake Helena's Ecoregion:	29.5	**5.8**	**0.10**		**Low Values**				

Appendix E: GWLF/Bathtub Modeling for Lake Helena

E.1.0 GWLF Modeling Assumptions

The GWLF model was chosen to simulate loads from rural and urban land uses in the watershed. Values for the input parameters were assigned based on available monitoring data or on default parameters suggested in the GWLF User's Manual (Haith et al., 1992). This section summarizes the bases for the hydrologic, erosion, sedimentation, and nutrient modeling assumptions.

E.1.1 Hydrologic Input

Hydrologic parameters for the GWLF model were obtained from a variety of sources. The Lake Helena watershed was divided into four subwatersheds – Prickly Pear Creek, Silver Creek, Tenmile Creek, and Lake Helena Overland. These subwatersheds were delineated using available stream and topographic information, and are shown in Figure E-1. Land use and land cover was determined using MRLC data and aerial photography, and the data are summarized in Appendix A. The MRLC data, collected in the early 1990s, was modified for this analysis to reflect increasing development in the Lake Helena watershed. Low-density residential land was increased by 17 percent and assumed that development occurred primarily on pasture, hay, and grassland.

Information about irrigation systems and irrigated land was obtained from the Helena Valley Irrigation district. This information was input into the model to account for flow withdrawals and irrigation returns. Appendix A further summarizes the irrigation characteristics of the Lake Helena watershed.

Curve numbers for each land use were based on the STATSGO soils database and recommended values in the GWLF User's Manual. Table E-1 lists the SCS curve numbers for the land uses in the Lake Helena Watershed. Initial estimates of soil capacity, river recession, evapotranspiration, daylight hours, and rainfall erosivity were also based on the GWLF User's Manual with some minor modifications made during model calibration.

Table E-1. SCS Curve Numbers for Land Uses in the Lake Helena Watershed

Land Use	Curve Number
Bare Rock	98
Transitional	60
Deciduous Forest	55
Evergreen Forest	60
Shrubland	48
Grassland	69
Woody Wetland	98
Herbaceous Wetland	98
Recent Clear-cut	70
Clear-cut Regrowth	65
Dirt Roads	82
Water	100
Pasture/Hay	58
Small Grains	75
Fallow	86
Row Crops	78
Low Density Residential	65
Comm/Ind/Trans	90
Urban Grasses	69

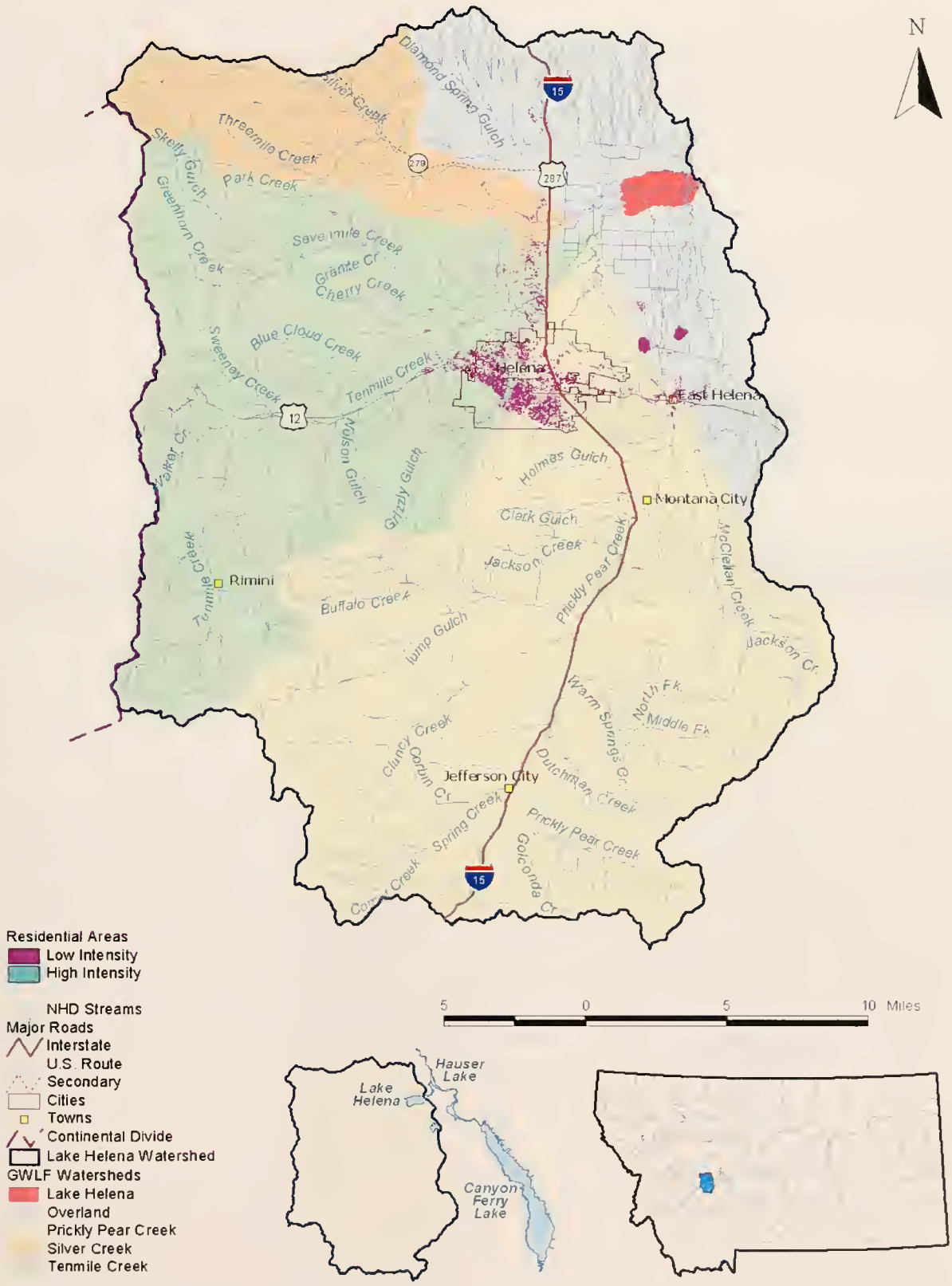


Figure E-1. Modeling subwatersheds in the Lake Helena TPA.

E.1.2 USLE Parameters

The USLE was set up based on general watershed assumptions applied to the entire watershed. The soil erodibility factor is 0.2, the slope length is 30 meters, the slope is 20 percent for the upland areas, 2 percent for the valley surrounding Lake Helena, and the practice factor for each land use is 1. Cover factors for each land use are based on GWLF default values and are summarized in Table E-2. The cover factor for dirt roads is based on the Watershed Characterization System estimates developed by Tetra Tech (2000).

The USLE equation estimates erosion. Delivered sediment is estimated by applying a sediment delivery ratio specific to each subbasin. The sediment delivery ratios for each subbasin are area-based as suggested in Haith et al. (1992).

Table E-2. Cover Factors by Land Use in the Lake Helena Watershed

Land Use	Cover Factor
Bare Rock	0.0001
Transitional	0.02
Deciduous Forest	0.003
Evergreen Forest	0.003
Shrubland	0.006
Grassland	0.01
Woody Wetland	0.003
Herbaceous Wetland	0.003
Recent Clear-cut	0.09
Clear-cut Regrowth	0.04
Dirt Roads	0.75
Water	0
Pasture/Hay	0.004
Small grains	0.03
Fallow	0.3
Row Crops	0.3
Low density residential	0.0065
Comm/Ind/Trans	0.01
Urban grasses	0.013

E.1.3 Soil Nutrient Concentrations

Soil nutrient concentrations are based on spatial distributions provided in the GWLF manual. The soil nitrogen concentration is 3,000 mg/kg based on Figure B-3 of the GWLF manual, which shows a median soil nitrogen content of 0.15 percent and suggests an enrichment ratio of 2. The soil phosphorus concentration is 440 mg/kg based on Figure B-4 in the GWLF manual which shows a soil P_2O_5 content of 0.05 percent (low end of range) and suggests an enrichment ratio of 2.

E.1.4 Groundwater Nutrient Concentrations

Groundwater nutrient concentrations were set to 0.07 mg-N/L and 0.012 mg-P/L based on baseflow measurements reported in the GWLF manual for forested watersheds.

E.1.5 Septic System Loading Data

The GWLF model requires an estimate of population served by septic systems to generate septic system loading rates. Daily per capita loading rates and plant uptake rates were set to GWLF default values and are summarized in Table E-3.

Table E-3. Septic System Loading Rates and Plant Uptake Rates

Parameter	Nitrogen	Phosphorus
Loading Rate (g/capita/d)	12	1.5
Plant Uptake Rate (g/d)	1.6	0.4

E.1.6 Point Sources

Three point sources in the Lake Helena Watershed contribute significant nutrient loading to the system; each discharges to the Prickly Pear Creek watershed. The GWLF model accounts for point source loads on a monthly basis (kg/mo). Average monthly loads were calculated from reported discharges from January 2000 to December 2002. Average loadings from each point source are presented in Table E-4 to Table E-6. The City of Helena WWTP loads are presented pre- and post-plant upgrades, which occurred in June 2001. It should be noted that the post-upgrade TP loads are in question because the loads increased following expansion. A possible lab or reporting error is being investigated. It should also be noted that the City of East Helena WWTP was upgraded in November/December 2003. The new system consists of a small, completely mixed aerated lagoon with a separate aerobic digestion cell for solids. Disinfection is with UV instead of the old chlorination system, and the new system has lined cells which do not seep to groundwater.

From April thru October, the majority of effluent from the City of Helena WWTP is used by a private landowner for irrigation of alfalfa fields (Clark, 2004). To model nutrient uptake, we assume that 95 percent of effluent is land applied during this time. Total phosphorus uptake is assumed 90 percent (reported ranges from 80 to 99 percent (USEPA, 2002a)). Ammonia and organic nitrogen are assumed taken up completely by plants. Nitrate/nitrite present in the effluent is assumed to pass through the system. According to the City of Helena WWTP DMRs, the average nitrate concentration prior to June 2001 was 0.18 mg-N/L; after the plant upgrades, the average nitrate concentration was 5.42 mg-N/L. The increase in nitrate concentrations is attributed to the upgraded ammonia removal process at the facility that results in more nitrogen in the effluent. Though plant upgrades have reduced the total nitrogen load by 70 percent, nitrogen loads passing through the irrigated fields are higher after the upgrades because more of the load is in the nitrate form.

Effluent that is not land applied travels approximately one mile through an open conduit before reaching Prickly Pear Creek (Ingman, 2004). Flow through the conduit is minimal from April through October. Nutrient uptake in the conduit is assumed negligible during the remaining months due to reduced biological activity under low-temperature conditions.

Table E-4. Average Monthly Nutrient Loads from the Evergreen Nursing Home (MT0023566)

Month	Average Total Nitrogen Load (kg/mo)	Average Total Phosphorus Load (kg/mo)
January	5.8	1.2
February	9.3	1.4
March	4.3	1.6
April	11.4	4.0
May	11.0	1.0
June	9.1	4.0
July	4.8	5.4
August	3.1	3.0
September	9.2	3.5
October	10.4	3.0
November	3.8	2.1
December	10.8	3.5

Table E-5. Average Monthly Nutrient Loads from the City of Helena, East WWTP (MT0022560)

Month	Average Total Nitrogen Load (kg/mo)	Average Total Phosphorus Load (kg/mo)
January	159.7	27.1
February	162.3	24.4
March	184.1	27.2
April	209.6	31.5
May	179.6	35.2
June	380.6	61.0
July	339.3	56.6
August	322.0	68.4
September	328.9	54.8
October	250.2	36.7
November	187.1	27.1
December	168.1	25.0

Table E-6. Average Monthly Nutrient Loads from the City of Helena WWTP Before and After Summer 2001 Plant Upgrades (MT0022641)

Month	Average Total Nitrogen Load Before Upgrades (kg/mo)	Average Total Phosphorus Load Before Upgrades (kg/mo)	Average Total Nitrogen Load After Upgrades (kg/mo)	Average Total Phosphorus Load After Upgrades (kg/mo)
January	12,859	1,625	2,501	1,758
February	11,767	1,698	3,053	8,166
March	12,088	1,721	4,773	2,864
April	10,945	1,697	3,307	7,027
May	8,205	801	3,438	8,312
June	7,012	1,102	3,312	1,313
July	9,803	719	2,894	4,129
August	8,605	1,467	3,657	941
September	8,940	543	2,512	1,725
October	9,341	1,636	2,833	1,607
November	12,859	1,562	2,962	696
December	12,934	1,401	1,711	2,224

E.1.7 Runoff Concentrations

Dissolved nutrient concentrations in runoff from each land use were set to GWLF default values and are summarized in Table E-7. Best professional judgment was used to estimate runoff concentrations from dirt roads.

Table E-7. Nutrient Runoff Concentrations for Rural Land Uses in the Lake Helena Watershed

Land Use	Nitrogen (mg/L)	Phosphorus (mg/L)
Bare Rock	0.09	0.009
Transitional	1.00	0.100
Deciduous Forest	0.07	0.012
Evergreen Forest	0.07	0.012
Shrubland	0.50	0.100
Grassland	3.00	0.250
Woody Wetland	0.07	0.012
Herbaceous Wetland	0.07	0.012
Recent Clear-cut	0.18	0.015
Clear-cut Regrowth	0.10	0.014
Dirt Roads	0.50	0.080
Water	0.07	0.012
Pasture/Hay	2.80	0.150
Small Grains	1.80	0.300
Fallow	2.60	0.100
Row Crops	2.90	0.260

E.1.8 Developed Land Buildup Rates

GWLF simulates nutrient loads from developed land uses through a buildup/washoff formulation. Buildup rates for nitrogen and phosphorus are based on weighted averages of pervious and impervious default values suggested in the GWLF manual (Table E-8).

Table E-8. Buildup Washoff Rates for Urban Land Uses in the Lake Helena Watershed

Land Use	Nitrogen (kg/ha-d)	Phosphorus (kg/ha-d)
Low Density Residential	0.020	0.0020
Comm/Ind/Trans	0.050	0.0050
Urban Grasses	0.012	0.0016

E.1.9 Forest Industry Land Uses

According to the "Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area" (USEPA, 2004), 93 percent of forest in the Lake Helena Watershed is timberland. In order to account for the impacts of silviculture, Tetra Tech apportioned 93 percent of the forestland identified in the MRLC database as timberland. Assuming a 90-yr harvesting cycle (Stuart, 2004), 1.11 percent of this timberland is assumed recently cut and assigned the land use "recent clear cut." To estimate the area of "clear-cut regrowth," we assumed a 5-yr regrowth period to re-establish 100 percent ground cover. The curve numbers, cover factors, and nutrient runoff concentrations of these silvicultural land uses vary from typical forestland as described in Tables E-1, E-2, and E-7. The area of dirt roads associated with timberland operations was based on best professional judgment. Two percent of the total forest area is allocated to dirt roads.

E.1.10 Grassland Under "Natural" Conditions

Under "Natural" conditions, grassland areas are assumed to have lower animal densities compared to grassland under existing conditions, which is often used for organized grazing. Under natural conditions, soil compaction is expected to be lower and vegetative cover higher. To account for these differences, grassland in the "Natural" scenario is assigned a curve number of 61 and a cover factor of 0.003.

E.1.11 GWLF Modeling Scenarios

Two sets of GWLF input files were generated to represent the Lake Helena modeling scenarios. The "Existing" scenario models current conditions by assigning current land uses (including urban development, agriculture, and silviculture), point sources, and septic system loads to the watershed. The number of total septic systems in the watershed varies by year based on the number of domestic wells. Information on the number of septic systems in was not available at the time of this report. The average household size is assumed 2.5 people per household. The "Natural" scenario models the watershed in its pre-disturbed condition: septic systems and point sources are removed from the loading and all urban, agricultural, and silvicultural land uses are converted to undisturbed forest. Table E-9 and Table E-10 summarize the inputs for the two modeling scenarios.

Table E-9. Land Use Areas for the Lake Helena Modeling Scenarios

Land Use	Existing (ac)	Natural (ac)
Bare Rock	385.6	385.6
Water	810.8	810.8
Transitional	789.0	-
Deciduous Forest	1,267.2	1,380.4
Evergreen Forest	148,346.7	216,452.0
Mixed Forest	18.2	18.2
Shrubland	37,412.7	37,412.7
Grassland	134,320.8	134,757.7
Pasture/Hay	13,504.5	-
Small Grains	21,404.4	-
Woody Wetland	626.7	626.7
Herbaceous Wetlands	126.8	126.8
Recent Clear-cut	1,684.1	-
Clear-cut Regrowth	8,420.5	-
Dirt Roads	3,259.6	-
Fallow	3,833.3	-
Row Crop	3,505.5	-
Low Density Residential	3,602.2	-
Commercial/Industrial/Transportation	7,064.2	-
Urban/Recreational Grasses	1,587.9	-

Table E-10. Population Served by Septic Systems in the Lake Helena Watershed Under Existing Conditions

Year	Normally Functioning	Short-Circuited[a]
1993	17,698	1,332
1994	17,964	1,352
1995	18,230	1,372
1996	18,496	1,392
1997	18,762	1,412
1998	19,028	1,432
1999	19,294	1,452
2000	19,560	1,472
2001	19,826	1,492
2002	20,092	1,512
2003	20,358	1,532

[a] Assumed 7 percent of onsite systems are short-circuiting based on national average (USEPA, 2002b).

E.2.0 GWLF Modeling Results

The GWLF model was used to simulate total nitrogen and total phosphorus loads to Lake Helena for the years 1993 through 2003. Figure E-2 and E-3 show the simulated nutrient loading to the lake in metric tons per year. There is a large increase in nutrient loading from "Natural" to "Existing" conditions, though a portion of the nitrogen increase has been offset by recent upgrades at the City of Helena WWTP. City of Helena nutrient loads are displayed in the figures to show the impacts of plant upgrades that occurred in 2001. There is some question to the validity of the total phosphorus loading estimates which are based on reported concentrations and flow rates in the City of Helena WWTP DMRs and the EPA point source query database. However, without additional data, we cannot justifiably alter the loading estimates.

Note that these estimates do not include loads from the Helena Valley Irrigation District, which are discussed in Section E.3.0.

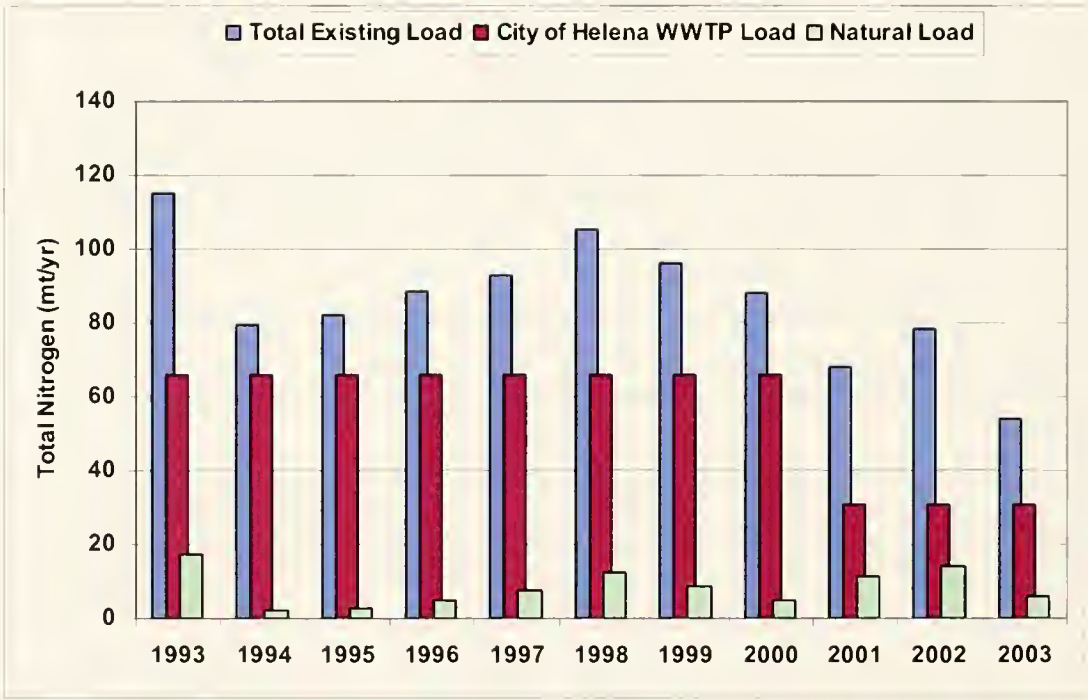


Figure E-2. Total Nitrogen Loads from the Lake Helena Watershed

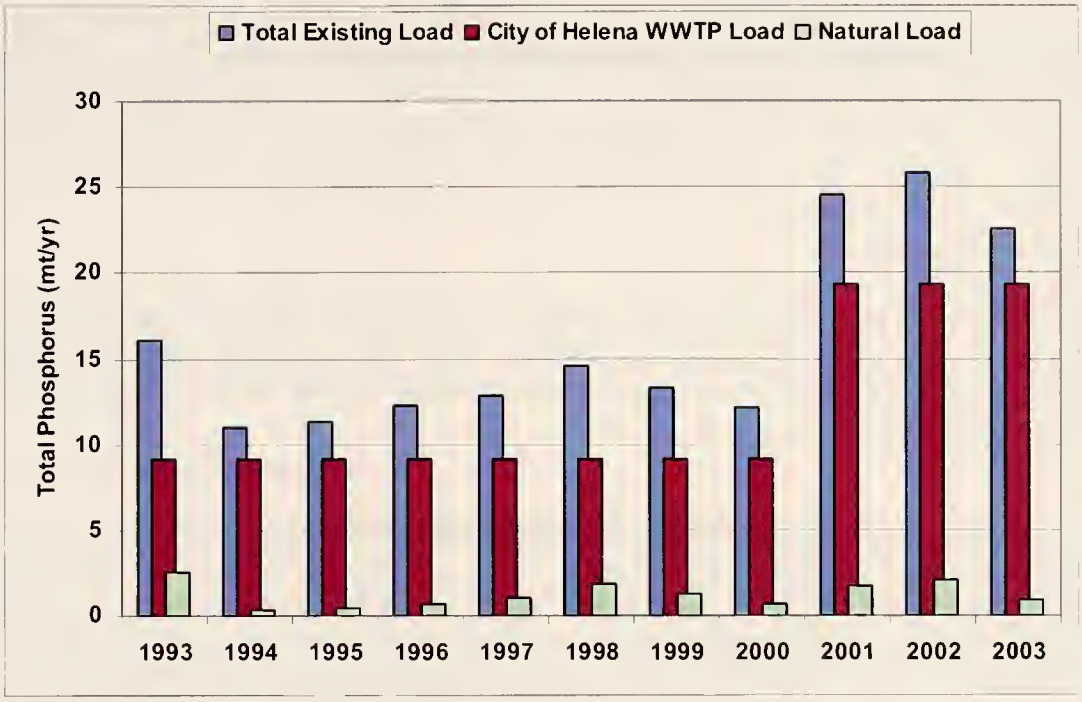


Figure E-3. Total Phosphorus Loads from the Lake Helena Watershed.

E.3.0 BATHTUB Model Setup

The ACOE BATHTUB model (Walker, 1987) was set up to simulate nutrient response in Lake Helena for the years 1993 through 2003. Nutrient loads and streamflows were simulated with the Generalized Watershed Loading Function (GWLF) model based on land use/land cover data and local meteorological data. Lake morphometry data were provided by Montana DEQ (Supple, 2004).

E.3.1 Lake Morphology

The BATHTUB model requires basic lake morphometric data (Table E-11) to assess residence time, net flow rate, and potential euphotic depth. Morphometric data are based on data provided by Montana DEQ. Because the lake is fairly uniform and no ponding occurs along the downstream reaches of the tributaries, segmentation is not required.

Table E-11. Lake Helena Morphology

Lake Volume (10^6 m^3)	13.45
Average Depth (m)	1.6
Surface area (km^2)	8.41

E.3.2 Atmospheric Deposition to Lake Helena

Atmospheric deposition can contribute a significant proportion of nitrogen loads directly to a lake surface, particularly when the ratio of watershed area to lake surface area is low. The Lake Helena watershed to lake area ratio is relatively high (192) so atmospheric deposition is not likely a major source of nutrient loading.

Total wet and dry nitrogen deposition rates to the lake surface (1.5 kg/ha) were based on CASTNET monitoring at Glacier National Park (GLR468) for 1997. Phosphorus deposition rates (primarily from wind blown dust) are generalized estimates (0.1 kg/ha).

E.3.3 Loads from the Helena Valley Irrigation System

The Helena Valley Irrigation District provides approximately 350 cfs of water pumped from the Missouri River to the Lake Helena Watershed from mid-April through September each year. A water balance based on weir measurements of canal and drain flows, crop water use, and evaporation from the open conduits was used to apportion flows to Lake Helena into groundwater recharge and drain overflow fractions. The results are presented in Table E-12 for a typical water year (2003).

Nutrient loads were estimated by applying appropriate concentrations to each source of flow from the irrigation district. Groundwater-recharge nutrient concentrations were based on suggested GWLF values for primarily agricultural watersheds: 0.71 mg-N/L and 0.104 mg-P/L. The nutrient concentrations in overflow drains were estimated by averaging values observed in three overflow drains during the summer of 2004 (0.71 mg-N/L and 0.037 mg-P/L). Resulting loads are 52 metric tons of total nitrogen per year and 6.6 metric tons of total phosphorus per year.

Table E-12. Water Balance for the Helena Valley Irrigation District

Month	Groundwater Recharge (cfs)	Drain Overflow (cfs)	Evaporation (cfs)	Total Flow to Lake Helena (cfs)
April	25.0	56.0	0.25	80.75
May	36.5	39.5	0.39	75.61
June	178.0	41.0	0.45	218.55
July	200.3	29.7	0.63	229.37
August	210.9	51.1	0.53	261.47
September	129.7	34.3	0.31	163.69

E.3.4 Inorganic Nutrient Fractions

BATHTUB requires an estimate of inorganic nutrient fractions for all loads to the lake. The inorganic nutrient fractions for the watershed loads were approximated from the ratios of dissolved nutrient load to total nutrient load predicted by GWLF for each year. Atmospheric and groundwater recharge loads from the irrigation system were assumed 100 percent inorganic; loads in the irrigation system drains were assumed 25 percent inorganic due to algal synthesis. Table E-13 summarizes the inorganic fractions of nutrient loads to Lake Helena for each modeling year.

Table E-13. Inorganic Nutrient Fractions to Lake Helena

Year	Fraction Inorganic Nitrogen	Fraction Inorganic Phosphorus
1993	0.71	0.73
1994	0.90	0.94
1995	0.88	0.92
1996	0.84	0.88
1997	0.82	0.85
1998	0.76	0.78
1999	0.80	0.83
2000	0.85	0.88
2001	0.70	0.86
2002	0.68	0.84
2003	0.79	0.92

E.3.5 Light Penetration in Lake Helena

The BATHTUB model requires average Secchi depth to determine the nonalgal turbidity in the lake. Secchi depth data were collected in Lake Helena during the summer of 2003 and ranged from 0.15 m to 1.07 m. Because data are only available for 2003, the average value of 0.41 m will be applied to all modeling years.

E.3.6 BATHTUB Lake Response Modeling

BATHTUB model output for the "Existing" scenario was first compared to conditions observed in Lake Helena in 2002 and 2003, which are represented by DEQ data collected on 8/9/2002 and Land &Water data collected on 6/26/2003 and 8/29/2003. The BATHTUB model offers the user several choices for nutrient sedimentation models, which determine the predicted in-lake concentrations from loading rates and residence time. Predicted phosphorus concentrations are in agreement with epilimnetic observations with the sedimentation factor set to 1.5 (mid-range for phosphorus (Walker, 1987)). Predicted nitrogen concentrations approach observed values with a sedimentation factor of 1 (no adjustment). It is not possible, however, to accurately estimate these factors with the available data.

Due to time constraints, sedimentation models are not described in this preliminary memo. Detailed information can be found in Walker (1987). Simulated nutrient concentrations were compared to observed values for the summer of 2002 and 2003 and are presented in 0.

Table E-14. Simulated Nutrient Concentrations Based on Four Sedimentation Models

Model Number	Model Description	Total Nitrogen (µg/L)		Total Phosphorus (µg/L)	
		2002	2003	2002	2003
1	Second Order, Available Nutrient	1,230	1,140	185	185
2	Second Order, Decay Rate	1,250	1,120	180	180
3	Second Order, Fixed	1,060	930	110	100
4	Canfied & Bachmann (1981)	1,040	910	110	100
---	Observed	1,480	820	155	226

The BATHTUB model uses simulated nutrient concentrations to predict growing season average chlorophyll *a* concentration in the euphotic zone. Again, the user has several options for simulation. This memo presents the results of modeling option 1, which accounts for nutrients, light availability, and flushing rate. Modeling option 1 was simulated for each nutrient model described in Table E-15. Simulated chlorophyll *a* concentrations are shown in Table E-15. The first four predictions are based on nutrient concentrations simulated by the four nutrient simulation models. A prediction was also simulated with observed nutrient concentrations. In 2002, predicted chlorophyll *a* concentrations were generally 60 percent below the observed mean (89 µg/L). In 2003, predicted chlorophyll *a* concentrations were typically 130 percent higher than the observed mean (15 µg/L).

Table E-15. Simulated Chlorophyll *a* Concentrations in Lake Helena Based on Various Nutrient Simulation Models and Observed Water Quality

Nutrient Simulation Model	Chlorophyll a (µg/L)	
	2002	2003
1	43	41
2	44	40
3	33	29
4	32	28
Observed Nutrient Concentrations	48	29
Average Observed Chlorophyll a Concentration	89	15

Nutrient model 1 was chosen to simulate nutrient concentrations in the lake because of its general applicability. Table E-16 reports the predicted chlorophyll *a* concentrations in Lake Helena for 1993 through 2003. Chlorophyll *a* concentrations are predicted to range from 40.9 to 47.8 µg/L with an average value of 45.2 µg/L. There is little variation in the model predictions from year to year. This is likely due to the steady inputs from point sources, septic systems, and the irrigation system, which result in near-constant concentrations of total nitrogen and total phosphorus in the lake.

Table E-16. Chlorophyll *a* Concentrations Predicted by the BATHTUB Model for Lake Helena

Year	Chlorophyll a (µg/L)
1993	47.8
1994	45.6
1995	45.8
1996	46.1
1997	46.5
1998	47.3
1999	46.8
2000	46.2
2001	42.5
2002	43.5
2003	40.9

E.4.0 BATHTUB Modeling Scenarios

The BATHTUB model was used to simulate lake response to the two land use scenarios modeled for Lake Helena. Watershed nutrient loads simulated by GWLF and loads estimated from the irrigation system were used to drive the eutrophication model. The contributions to the additional nutrient loads (year 2003 loads relative to natural conditions) are summarized in Figure E-4 and E-5.

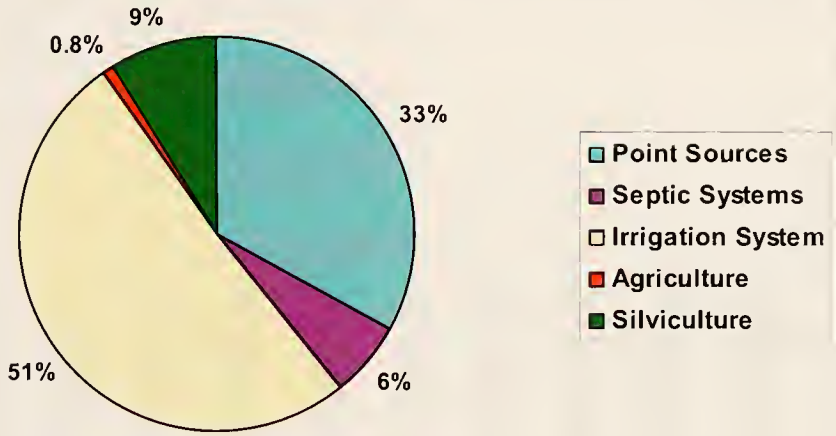


Figure E-4. Sources of Additional Total Nitrogen Loading (Year 2003) in the Lake Helena Watershed Compared to Natural Conditions

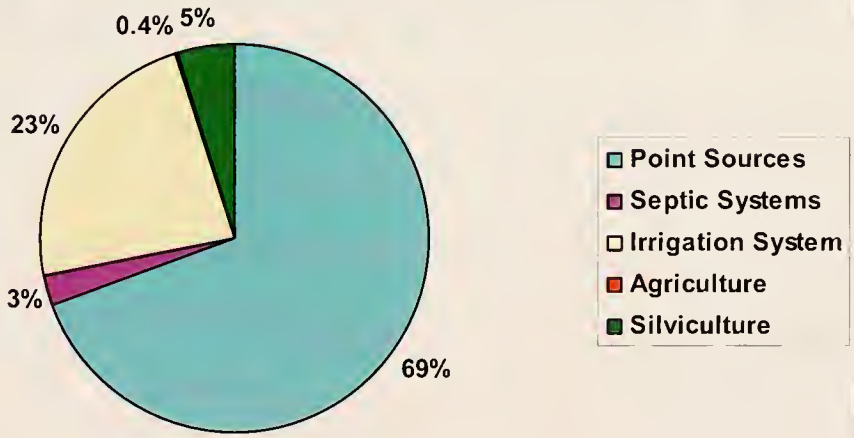


Figure E-5. Sources of Additional Total Phosphorus Loading (Year 2003) in the Lake Helena Watershed Compared to Natural Conditions

Nutrient sedimentation model 1 is used to simulate nitrogen and phosphorus concentrations from input loads. Chlorophyll *a* model 1, which accounts for nutrients, light availability, and flushing rate, is used to estimate chlorophyll *a* concentrations.

Predicted levels of eutrophication under two land use scenarios were compared. The "Existing" scenario accounts for current land use, point sources, septic systems, and the Helena Valley Irrigation System. The "Natural" scenario converts all land uses to an undisturbed state and removes the point sources, septic systems, and irrigation system from the loading. The simulated residence time in Lake Helena increases under natural conditions because additional flows from the irrigation system are not flushing through the system each summer. Figure E-6 compares the predicted chlorophyll *a* concentrations under each scenario. Under natural conditions, the mean predicted chlorophyll *a* concentration across all years is 9.3 µg/L; under existing conditions, the mean predicted concentration is 45.2 µg/L.

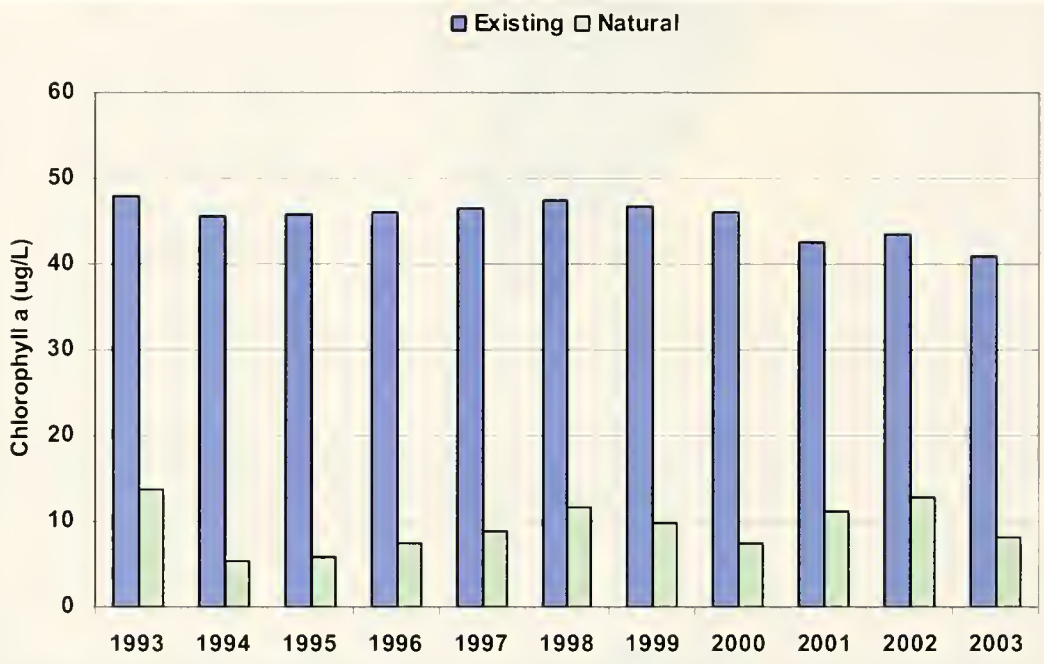


Figure E-6. Chlorophyll *a* Concentrations Simulated for Two Modeling Scenarios

E.5.0 Conclusions

It is difficult to calibrate the GWLF/BATHTUB model for the Lake Helena Watershed with the available data (one sampling date in 2002 and two dates in 2003). In addition, applying constant monthly loads from the Helena Valley Irrigation System, point sources, and septic systems may oversimplify the loading from these sources, which may explain the relatively constant chlorophyll *a* predictions for the lake across all modeling years. However, the BATHTUB model does predict an average chlorophyll *a* concentration of 45 µg/L, which is also the average of all samples collected in both 2002 and 2003 (45 µg/L). Thus, the model may be accurately depicting general eutrophication of the lake, rather than day-to-day variation detected by limited sampling data.

Results of the GWLF/BATHTUB model for this watershed under natural conditions are probably more reliable than for existing conditions because 1) transport parameters for undisturbed land uses are well established, and 2) the constant-input assumptions concerning the irrigation system, point sources, and septic systems do not apply. Under the natural scenario, chlorophyll *a* is predicted to range from 5.2 µg/L to 13.7 µg/L with a mean of 9.3 µg/L. It is not likely, therefore, that Lake Helena will ever achieve the current water quality target of 2.2 µg/L. The target is based on trophic state indices observed in shallow, reference lakes in Ecoregion II. Lake Helena has a relatively high ratio of watershed area to lake area. Even under natural conditions, total loading from upland areas would be expected to cause mild eutrophication in a lake this size.

E.6.0 References

Canfield, D.E. and R.W. Bachmann. 1981. Prediction of total phosphorus concentrations, chlorophyll-*a* and Secchi disc in natural and artificial lakes. *Can. J. Fish. Aq. Sci.*, 38, 414-423.

Clark, Don. 2004. Personal communication to Julie Tsatsaros via email dated November 8, 2004 concerning the City of Helena WWTP.

Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.

Ingman, G. 2004. Personal communication during conference call dated November 4, 2004 concerning the City of Helena WWTP.

Stuart, Bo. 2004. Personal communication to Taylor Greenup via email dated November 8, 2004 concerning the Helena National Forest.

Tetra Tech. 2000. Watershed Characterization System User's Guide, Version 1.1. Developed for the Environmental Protection Agency, Region 4.

USEPA. 2002a. Wastewater Technology Fact Sheet, Slow Rate Land Treatment. EPA 832-F-02-012, September 2002.

USEPA. 2002b. *Onsite Wastewaste Treatment Systems Manual.* EPA/625/R-00/008. February 2002

USEPA. 2004. Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed Planning Area.

Walker, W.W., Jr. 1987. Empirical Methods for Predicting Eutrophication in Impoundments. Report 4–Phase III: Applications Manual. Technical Report E-81-9. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Appendix F: Sediment Data for Impairment Status Determination

Helena National Forest Riparian Land Type Aggregates

Table 1. Desired Riparian and Stream Morphological Characteristics for Helena National Forest Riparian Aggregates

Aggregate	D-50	D84	Sinuosity	Confinement	Width/Depth Ratio	% Fines	Rosgen
1 Limestone/ Mtn. Slopes & Ridges	4-16mm FG-MG	32-128mm VCG-SC	Low <1.2	Confined <2.7	Moderate 10-14	32 - 44	A4, B4a
2 Volcanic Rock/ Mtn. Slopes & Ridges	8-32mm MG-CG	128-512mm LC-SB	Low 1.05-1.3	Confined 1.4-2.5	4.8-10	30 - 42	A3,4 B4a
3 Metasedimentary Rock/ Mtn. Slopes & Ridges	2-8mm VFG-FG	16-128mm CG-SC	Low 1.01-1.4	Confined 1.2-3.3	8-12	34 - 46	A4, B4a
4 Metasedimentary & Volcanic Rock/ Mountain Slopes	4-16 mm FG-MG	32-128 mm VCG-SC	Mod 1.1-1.4	Mod 2.7-5.4	6-10	30 - 46	A4, B4a
5 Mixed Colluvial Deposits	.062-32MM Silt-CG	16-128 CG-SB	Mod-High 1.02-1.5	Unconfined 2.3-5.7	NA 4-9	36 - 42	Wetlands C4, B4
6 Mixed Landslides	.062-32MM Silt-CG	128-512 LC-SB	Derranged >1.5	Unconfined 2.7-5.7	NA	36 - 42	Bogs/Seeps B6,5,4
8 Limestone & Metasedimentary Rock/ Mtn. Slopes	2-8mm VFG-FG	32-128mm VCG-SC	Low <1.2	Confined <2.7	<12	32 - 46	A4, B4a
9 Rhyolitic Rock/ Mountain Slopes & Ridges	2-16 mm VFG-MG	16-64 mm CG-VCG	Mod 1.2-1.4	Unconfined >5.4	3.4-10	30-42	A4
10 Granitic Rock/ Mtn. Slopes & Ridges	1-4mm VCS-VFG	256-2048mm SB-LB	Low 1.02-1.1	Confined <2.7	8-15	48 - 60	A2/A5 B2/B5
11 Granitic Rock/ Rolling Uplands	1-4mm VCS-VFG	256-1024 SB-MB	Low 1.02-1.2	Confined <2.7	5-8	48 - 60	B2/B5 A2/A5

Aggregate	D-50	D84	Sinuosity	Confinement	Width/Depth Ratio	% Fines	Rosgen
12 Limestone/ Dip Slopes	8-32mm MG-CG	16-128 CG-SC	Low 1.1-1.3	Confined <2.7	12+	32 - 44	B4a/A4
13 Limestone/ Structural Breaklands	4-16 mm FG-MG	16-64 mm CG-VCG	Low <1.2	Confined <2.7	6-7	32 - 44	A4, A1a
14 Metasedimentary & Volcanic Rock/ Structural Breaklands	4-16 mm FG-MG	32-128 mm VCG-Sc	Low <1.2	Confined <2.7	12+	30 - 46	A4, B4a
15 Metasedimentary/ Structural Benches	2-8mm VFG-FG	16-128mm CG-SC	Low-Med 1.2-1.4	Mod 2.7-5.4	12+	34 - 46	B4
16 Metasedimentary/ Structural Breaklands	2-8 mm VFG-FG	32-128 VCG-SC	Low 1.0-1.1	Confined <2.7	4.5-12	34 - 46	B4, A4
17 Assorted Geology/ Structural Breaklands (scree)	64-256 mm SC-LC	128-512 mm LC-SB	NA	Unconfined >5.4	12+	30 - 42	A1, A2
18 Volcanic Rock/ Rolling Uplands	8-64 mm MG-VCG	32-256 mm VCG-LC	Low 1.1-1.3	Moderate 2.4-2.7	Low 9-10	30 - 42	B4, B3
19 Metasedimentary Rock/ Rolling Uplands	2-8 mm VFG-FG	16-128 mm CG-SC	Mod 1.2-1.4	Moderate 2.7	8-12	34 - 46	B4

Aggregate	D-50	D84	Sinuosity	Confinement	Width/Depth Ratio	% Fines	Rosgen
20 Metasedimentary & Volcanic Rock/ Glacial Trough Walls	32-128 VCG-SC	128-2048mm LC-LB	ow <1.2	Confined <2.4	3.9-12+	26 - 32	A3
21 Metasedimentary Rock Cirque Basins	16-BR MG-Bed .062-4mm Silt-VFG	32-BR CG-Bed 4-16mm FG-MG	Low <1.1 High >1.4	Unconfined Unconfined >5.4	5-7	26 - 32 48 - 70	A1a,3 E5
22 Granitic Rock/ Glaciated Mtn. Slopes	1-4mm VCS-VFG	128-2048mm LC-MB	Low 1.05-1.15	confined <1.7	8.5-9.4	36 - 42	A2, B2
23 Granitic Rock/ Glacial Trough Walss	32-128 VCG-SC	256-1024mm SB-MB	Low <1.2	High <1.7	8.5-9.4	36 - 42	A2, A3
24 Granitic Glacial Till/ Moraines	16-128mm CG-SC	256-1024mm SB-MB	Mod-Low 1.1-1.3	Mod 1.7-3.7	Low 2.2-5.2	36 - 42	B3, B2
25 Compact Loamy Glacial Till/ Moraines	16--64mm CG-VCG	128-512mm LC-SB	Low-Mod 1.1-1.3	Confined-Unconfined 1.1->10	23-33	30 - 36	B2, B3 DA, D3
26 Volcanic & Metasedimentary Compact Till/ Moraines	4-256mm FG-LC	256-1024mm SB-MB	Low <1.2	Mod 2.2-5.4	3.9-6.8	28 - 36	B2, B3
27 Friable Loamy Glacial Till Moraines	.062-2mm Silt Clay Sand	8-512mm MG-SB	Unconfined-High-Mod >1.4	High- Mod >5.4	NA	28 - 60	E6, E5 B2, B3

Aggregate	D-50	D84	Sinuosity	Confinement	Width/Depth Ratio	% Fines	Rosgen
28 Metasedimentary Rock & Till/ Glaciated Mtn . Slopes	16-256mm CG-LC	256-2048mm SB-LB	Low 1.04-1.2	Confined <2.7	10-22	26 - 40	A2, B2 A3, B3
29 Alluvial (Borolls)/ Floodplains & terraces	2-32mm CS-MG	8-256mm FG-LC	Mod-High 1.07-1.57	Unconfined	19-41	26 - 38	C4,B4 C3,B3
30 Alluvail (Aquolls)/ Floodplains & Terraces	8-64mm FG-VFG	128-2048mm LC-LB	Low-High 1.06-1.36	Confined 1.35-1.390	29-34	26 - 38	C4, C3
31 Alluvial/ Fans	8-32mm MG-CG	16-128mm CG-SC	Mod-High 1.2-1.4	Unconfined 2.7+	High >12	26 - 38	C4, C3

Helena National Forest McNeil Core Dataset

Table 2. **Helena National Forest McNeil Core Database**

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Springs Creek	01-Jul-93	0.00	247.00	259.00	226.00	110.00	64.00	248.00	500.00	294.00	23.00	1971.00	57.28	16.08	37.95	5.19	1	8N	2W	SE30	11
Springs Creek	01-Jul-93	0.00	1254.00	522.00	376.00	121.00	56.00	158.00	291.00	160.00	8.00	2946.00	22.84	5.70	15.24	19.65	1	8N	2W	SE30	11
Springs Creek	01-Jul-93	0.00	323.00	781.00	146.00	82.00	32.00	75.00	132.00	130.00	118.00	1819.00	26.77	13.63	11.38	12.02	1	8N	2W	SE30	11
Springs Creek	01-Jul-93	0.00	0.00	55.00	458.00	285.00	100.00	178.00	148.00	333.00	27.00	1584.00	49.62	22.73	20.58	4.31	2	8N	2W	SE30	11
Springs Creek	01-Jul-93	0.00	453.00	1001.00	414.00	221.00	64.00	166.00	259.00	219.00	18.00	2815.00	25.79	8.42	15.10	14.15	3	8N	2W	SE30	11
Springs Creek	01-Jul-93	0.00	0.00	272.00	253.00	164.00	67.00	165.00	274.00	411.00	10.00	1616.00	57.36	26.05	27.17	3.93	4	8N	2W	SW30	11
Dutchman Creek	02-Aug-93	0.00	0.00	959.00	520.00	264.00	91.00	197.00	229.00	300.00	15.00	2575.00	32.31	12.23	16.54	9.71	1	7N	3W	NE3	11
Dutchman Creek	02-Aug-93	0.00	268.00	520.00	461.00	329.00	103.00	171.00	150.00	193.00	11.00	2206.00	28.47	9.25	14.55	11.49	2	7N	3W	NE3	11
Dutchman Creek	02-Aug-93	0.00	297.00	387.00	375.00	211.00	70.00	106.00	124.00	234.00	20.00	1824.00	30.37	13.93	12.61	10.50	3	7N	3W	NE3	11
Dutchman Creek	02-Aug-93	0.00	380.00	409.00	288.00	371.00	112.00	194.00	169.00	228.00	10.00	2161.00	32.99	11.01	16.80	10.40	4	7N	3W	NE3	11
Dutchman Creek	02-Aug-93	0.00	0.00	513.00	612.00	327.00	102.00	142.00	94.00	50.00	7.00	1847.00	21.39	3.09	12.78	13.06	4	7N	3W	NE3	11
Dutchman Creek	02-Aug-93	0.00	0.00	268.00	770.00	656.00	207.00	284.00	119.00	93.00	13.00	2420.00	29.59	4.38	16.65	9.32	4	7N	3W	NE3	11
East Tributary	28-Aug-98	0.00	0.00	588.00	422.00	254.00	71.00	161.00	153.00	109.00	16.00	1774.00	28.75	7.05	17.70	10.79	1	12N	8W	12	3
East Tributary	28-Aug-98	0.00	0.00	446.00	711.00	538.00	146.00	294.00	190.00	41.00	14.00	2380.00	28.78	2.31	20.34	10.37	2	12N	8W	12	3
East Tributary	28-Aug-98	0.00	384.00	672.00	324.00	353.00	107.00	253.00	233.00	56.00	14.00	2396.00	27.67	2.92	20.28	13.97	3	12N	8W	12	3
East Tributary	28-Aug-98	0.00	411.00	545.00	536.00	537.00	155.00	265.00	136.00	26.00	24.00	2635.00	23.00	1.90	15.22	14.50	4	12N	8W	12	3
East Tributary	28-Aug-98	0.00	173.00	504.00	658.00	488.00	161.00	314.00	194.00	51.00	21.00	2584.00	29.06	3.17	19.66	11.30	5	12N	8W	12	3
East Tributary	28-Aug-98	0.00	0.00	157.00	266.00	300.00	72.00	116.00	49.00	19.00	12.00	991.00	27.04	3.13	15.65	9.89	6	12N	8W	12	3
East Tributary	28-Aug-98	0.00	558.00	401.00	583.00	468.00	165.00	324.00	182.00	28.00	8.00	2717.00	26.02	1.32	18.62	14.59	7	12N	8W	12	3
Skelly Gulch	01-Oct-91	0.00	790.10	1322.30	1247.00	1584.50	0.00	1324.30	686.50	501.50	367.00	7823.30	36.80	11.10	25.70	7.49	1	11N	6W	SE24	3
Skelly Gulch	01-Oct-91	0.00	1077.20	1329.80	1205.10	1376.90	0.00	1075.00	671.00	509.40	372.00	7616.40	34.50	11.57	22.92	8.21	1	11N	6W	SE24	3
Skelly Gulch	01-Oct-91	0.00	1284.40	994.40	989.30	1196.00	0.00	795.10	625.20	562.40	377.10	6823.90	34.58	13.77	20.81	8.01	1	11N	6W	SE24	3
Skelly Gulch	01-Oct-91	0.00	0.00	1259.80	1127.30	1268.30	0.00	1186.60	33.30	811.50	386.30	6073.10	39.81	19.72	20.09	5.53	1	11N	6W	SE24	3
Maupin Creek	12-Sep-95	0.00	325.00	687.00	579.00	183.00	60.00	129.00	185.00	270.00	32.00	2450.00	27.59	12.33	12.82	11.63	1	8N	2W	NE5	11
Maupin Creek	12-Sep-95	0.00	0.00	397.00	328.00	236.00	146.00	375.00	371.00	267.00	37.00	2157.00	55.45	14.09	34.59	5.12	2	8N	2W	NE5	11
Maupin Creek	12-Sep-95	0.00	720.00	1267.00	502.00	231.00	127.00	308.00	361.00	323.00	32.00	3871.00	29.73	9.17	17.28	13.34	3	8N	2W	NE5	11
Maupin Creek	12-Sep-95	1519.00	0.00	453.00	431.00	209.00	95.00	215.00	250.00	277.00	82.00	3531.00	26.03	10.17	13.17	18.37	4	8N	2W	NE5	11
Maupin Creek	12-Sep-95	0.00	0.00	947.00	620.00	271.00	120.00	234.00	284.00	308.00	52.00	2836.00	35.19	12.69	18.27	8.64	5	8N	2W	NE5	11
Maupin Creek	12-Sep-95	0.00	467.00	736.00	605.00	284.00	120.00	257.00	344.00	455.00	56.00	3344.00	37.44	15.58	18.27	8.62	6	8N	2W	NE5	11
Castle Fork (Deep Creek)	15-Jul-91	0.00	86.00	806.00	472.00	601.00	206.00	386.00	288.00	70.00	17.30	2932.30	32.99	2.98	22.99	10.54	1	7N	5E	20A	3
Castle Fork (Deep Creek)	15-Jul-91	0.00	0.00	651.00	843.00	560.00	173.00	348.00	238.00	153.00	66.00	3032.00	32.26	7.22	19.33	8.91	2	7N	5E	20A	3
Castle Fork (Deep Creek)	15-Jul-91	0.00	566.00	855.00	530.00	551.00	188.00	404.00	322.00	94.00	31.00	3541.00	29.34	3.53	20.50	12.99	3	7N	5E	20A	3
Castle Fork (Deep Creek)	15-Jul-91	0.00	236.00	310.00	397.00	425.00	124.00	279.00	334.00	143.00	33.00	2281.00	40.03	7.72	26.87	8.00	4	7N	5E	20A	3
Castle Fork (Deep Creek)	15-Jul-91	0.00	316.00	636.00	435.00	530.00	179.00	372.00	305.00	128.00	32.00	2933.00	34.64	5.46	23.08	10.24	5	7N	5E	20A	3
Castle Fork (Deep Creek)	15-Jul-91	0.00	0.00	646.00	648.00	440.00	130.00	319.00	400.00	130.00	26.00	2739.00	36.69	5.70	26.25	8.58	6	7N	5E	20A	3
Russell Fork (Deep Creek)	25-Jul-91	0.00	590.00	967.00	717.00	507.00	155.00	325.00	261.00	69.00	23.00	3614.00	23.05	2.55	16.21	15.47	1	7N	5E	20C	31
Russell Fork (Deep Creek)	25-Jul-91	0.00	0.00	1037.00	554.00	349.00	86.00	199.00	342.00	342.00	54.00	2963.00	34.53	13.36	18.26	8.43	2	7N	5E	20C	31
Russell Fork (Deep Creek)	25-Jul-91	754.00	515.00	992.00	879.00	593.00	181.00	427.00	446.00	140.00	29.00	4956.00	24.68	3.41	17.62	16.60	2	7N	5E	20C	31
Russell Fork (Deep Creek)	25-Jul-91	0.00	453.00	387.00	822.00	487.00	137.00	319.00	376.00	142.00	28.00	3151.00	31.80	5.40	22.06	10.56	2	7N	5E	20C	31
Russell Fork (Deep Creek)	25-Jul-91	1348.00	770.00	691.00	583.00	546.00	154.00	275.00	211.00	149.00	44.00	4771.00	17.46	4.05	10.19	24.00	3	7N	5E	20B	31
Russell Fork (Deep Creek)	25-Jul-91	0.00	400.00	960.00	800.00	638.00	186.00	420.00	300.00	53.00	18.00	3775.00	25.88	1.88	19.07	13.57	4	7N	5E	20B	31
Property)	13-Nov-91	0.00	305.20	323.10	1150.60	416.70	591.80	1394.80	1060.60	1252.60	36.70	6542.10	66.29	19.71	37.53	3.97	2				
Property)	13-Nov-91	0.00	0.00	130.50	679.20	281.10	356.90	812.30	983.50	1777.40	77.20	5018.10	78.06	36.96	33.79	2.05	2				
Property)	13-Nov-91	0.00	0.00	285.00	1069.40	320.10	424.00	948.00	1062.70	913.30	24.20	5066.70	66.95	18.50	39.68	3.68	2			State sec	
Property)	13-Nov-91	0.00	0.00	1093.20	1559.60	445.50	529.30	1182.10	679.70	736.60	37.70	6263.70	50.54	12.36	29.72	6.40	2			State sec	
Property)	13-Nov-91	0.00	205.50	806.20	1527.60	364.70	607.00	1135.30	454.30	718.40	24.60	5843.60	50.30	12.71	27.20	6.77	2				
Sulphur Bar Creek	25-Jul-88	0.00	207.00	894.00	1032.00	948.00	333.00	703.00	895.00	481.00	145.00	5638.00	45.35	11.10	28.24	6.25	1	7N	4E	35	3
Sulphur Bar Creek	25-Jul-88	0.00	0.00	798.00	1323.00	870.00	323.00	654.00	680.00	416.00	158.00	5232.00	42.83	10.97	25.69	6.32	2	7N	4E	35	3
Sulphur Bar Creek	25-Jul-88	0.00	0.00	410.00	819.00	1029.00	389.00	852.00	850.00	416.00	154.00	4919.00	54.10	11.59	34.60	4.64	3	7N	4E	35	3
Sulphur Bar Creek	25-Jul-88	0.00	393.00	973.00	1320.00	1046.00	265.00	398.00	324.00	330.00	105.00	5154.00	27.59	8.44	14.01	10.13	3	7N	4E	35	3
Sulphur Bar Creek	25-Jul-88	0.00	345.00	918.00	956.00	831.00	336.00	750.00	647.00	402.00	234.00	5429.00	43.64	11.71	25.73	6.61	3	7N	4E	35	3
Sulphur Bar Creek	25-Jul-88	0.00	0.00	259.00	1076.00	967.00	329.00	659.00	609.00	558.00	273.00	4740.00	51.43	17.53	26.96	4.08	4	7N	4E	35	3
Sulphur Bar Creek	25-Jul-88	0.00	0.00	886.00	820.00	622.00	255.00	501.00	463.00	497.00	235.00	4279.00	45.59	17.11	22.53	5.36	5	7N	4E	35	3
Sulphur Bar Creek	25-Jul-88	0.00	174.00	833.00	832.00	806.00	322.00	733.00	738.00	360.00	158.00	4966.00	46.74	10.63	29.62	6.16	6	7N	4E	35	3
Sulphur Bar Creek	25-Jul-88	0.00	272.00	748.00	998.00	755.00	273.00	611.00	619.00	382.00	233.00	4891.00	43.30	12.57	25.15	6.26	7	7N	4E	35	3
Sulphur Bar Creek	25-Jul-88	0.00	983.00	605.00	919.00	904.00	323.00	718.00	558.00	185.00	197.00	5392.00	36.74	7.08	23.65	9.21	8	7N	4E	35	3
Deep Creek	25-Jul-87	0.00	0.00	655.00	866.00	695.00	241.00	765.00	844.00	753.00	45.00	4874.00	54.53	16.58	33.01	4.71	1				

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Deep Creek	25-Jul-87	0.00	295.00	694.00	899.00	689.00	214.00	671.00	541.00	323.00	83.00	4409.00	41.55	9.21	27.49	7.54	2				
Deep Creek	25-Jul-87	0.00	0.00	574.00	1500.00	1228.00	290.00	679.00	540.00	491.00	53.00	5355.00	38.34	10.16	22.76	6.90	3				
Deep Creek	25-Jul-87	0.00	219.00	327.00	1143.00	1477.00	397.00	916.00	371.00	255.00	42.00	5147.00	38.49	5.77	25.00	7.66	4				
Deep Creek	25-Jul-87	0.00	690.00	540.00	743.00	594.00	225.00	732.00	426.00	211.00	75.00	4236.00	39.40	6.75	27.24	9.35	5				
Deep Creek	25-Jul-87	0.00	1677.00	729.00	798.00	875.00	290.00	729.00	364.00	323.00	100.00	5885.00	30.69	7.19	18.57	12.70	6				
Deep Creek	25-Jul-87	0.00	568.00	954.00	1169.00	693.00	176.00	382.00	137.00	147.00	90.00	4316.00	21.59	5.49	12.03	13.64	7				
Deep Creek	25-Jul-87	0.00	872.00	582.00	832.00	863.00	308.00	793.00	402.00	165.00	39.00	4856.00	35.15	4.20	24.61	10.92	8				
Deep Creek	06-Jun-88	367.00	865.00	981.00	982.00	692.00	231.00	459.00	631.00	581.00	86.00	5875.00	33.84	11.35	18.55	10.50	1	7N	4E	NW28	29
Deep Creek	06-Jun-88	0.00	0.00	939.00	425.00	886.00	373.00	799.00	876.00	683.00	105.00	5086.00	55.76	15.49	32.93	4.70	2	7N	4E	NW28	29
Deep Creek	06-Jun-88	0.00	553.00	712.00	1215.00	717.00	251.00	528.00	614.00	604.00	77.00	5271.00	39.35	12.92	21.67	7.70	3	7N	4E	NW28	29
Deep Creek	06-Jun-88	0.00	701.00	1263.00	971.00	1035.00	378.00	795.00	933.00	700.00	116.00	6862.00	42.58	11.89	25.18	7.49	4	7N	4E	NW28	29
Deep Creek	06-Jun-88	1243.00	566.00	436.00	852.00	787.00	294.00	656.00	714.00	357.00	76.00	5991.00	35.17	7.23	23.03	12.16	5	7N	4E	NW28	29
Deep Creek	06-Jun-88	0.00	135.00	1160.00	1333.00	993.00	262.00	561.00	1000.00	594.00	39.00	6077.00	40.41	10.42	25.69	7.21	6	7N	4E	SW25	29
Deep Creek	06-Jun-88	0.00	0.00	860.00	570.00	606.00	234.00	650.00	1184.00	759.00	35.00	4908.00	58.52	16.18	37.57	4.41	7	7N	4E	SW25	29
Deep Creek	06-Jun-88	0.00	1055.00	1250.00	901.00	716.00	206.00	334.00	357.00	409.00	136.00	5364.00	26.88	10.16	12.88	12.12	8	7N	4E	SW25	29
Deep Creek	06-Jun-88	0.00	1411.00	955.00	938.00	665.00	172.00	260.00	235.00	237.00	104.00	4977.00	20.25	6.85	9.95	16.03	8	7N	4E	SW25	29
Deep Creek	06-Jun-88	0.00	0.00	1557.00	1586.00	1299.00	329.00	442.00	328.00	457.00	227.00	6235.00	28.76	11.13	12.35	8.63	8	7N	4E	SW25	29
Deep Creek	20-Nov-89	689.00	612.00	919.00	616.00	875.00	329.00	719.00	670.00	367.00	220.00	6016.00	38.31	9.76	23.09	9.52	1	7N	4E	30	29
Deep Creek	20-Nov-89	0.00	982.00	1042.00	803.00	803.00	281.00	547.00	735.00	332.00	73.00	5598.00	35.16	7.23	22.90	10.34	2	7N	4E	SE30	29
Deep Creek	20-Nov-89	0.00	108.00	1382.00	756.00	530.00	222.00	466.00	496.00	237.00	45.00	4242.00	34.56	6.65	22.68	10.03	3	7N	4E	NW29	29
Deep Creek	20-Nov-89	0.00	531.00	1227.00	659.00	589.00	212.00	440.00	500.00	216.00	76.00	4450.00	32.45	6.56	21.12	11.04	4	7N	4E	27	29
Deep Creek	20-Nov-89	0.00	511.00	1127.00	875.00	647.00	179.00	367.00	792.00	616.00	127.00	5241.00	39.71	14.18	22.11	7.44	5	7N	4E	SE27	29
Deep Creek	20-Nov-89	0.00	779.00	527.00	799.00	597.00	184.00	425.00	538.00	306.00	61.00	4216.00	35.91	8.70	22.84	9.58	6	7N	4E	SW26	29
Deep Creek	20-Nov-89	0.00	91.00	622.00	1708.00	1152.00	285.00	477.00	187.00	195.00	223.00	4940.00	27.67	8.46	13.44	8.49	7	7N	4E	SE26	29
Deep Creek	20-Nov-89	0.00	1273.00	745.00	955.00	703.00	219.00	392.00	256.00	131.00	46.00	4720.00	22.12	3.75	13.73	16.17	8	7N	4E	SE26	29
Deep Creek	20-Nov-89	0.00	0.00	1281.00	690.00	613.00	214.00	393.00	453.00	266.00	100.00	4000.00	35.40	9.15	20.90	8.63	8	7N	4E	SE26	29
Deep Creek	20-Nov-89	0.00	0.00	1179.00	1059.00	832.00	311.00	646.00	683.00	212.00	51.00	4983.00	38.19	5.28	25.67	8.51	8	7N	4E	SE26	29
Deep Creek	04-Nov-93	0.00	484.00	710.00	573.00	461.00	137.00	248.00	395.00	248.00	83.00	3349.00	33.17	9.88	19.20	9.78	1	7N	4E	SE30	29
Deep Creek	04-Nov-93	0.00	0.00	588.00	761.00	484.00	137.00	279.00	252.00	82.00	70.00	2653.00	30.91	5.73	20.02	9.21	2	7N	4E	SE30	29
Deep Creek	04-Nov-93	0.00	0.00	504.00	674.00	395.00	123.00	201.00	226.00	247.00	100.00	2470.00	36.32	14.05	17.29	6.83	3	7N	4E	NW29	29
Deep Creek	04-Nov-93	0.00	0.00	1108.00	681.00	495.00	150.00	278.00	356.00	125.00	33.00	3236.00	29.42	4.88	19.90	10.92	4	7N	4E	NW27	29
Deep Creek	04-Nov-93	0.00	0.00	1110.00	685.00	388.00	105.00	226.00	456.00	306.00	53.00	3329.00	34.42	10.78	20.49	8.72	5	7N	4E	SE27	29
Deep Creek	04-Nov-93	0.00	0.00	922.00	372.00	461.00	144.00	307.00	338.00	90.00	30.00	2664.00	34.12	4.50	24.21	9.95	6	7N	4E	SW26	29
Deep Creek	08-Nov-94	0.00	1015.00	621.00	633.00	465.00	107.00	219.00	247.00	199.00	41.00	3547.00	22.92	6.77	13.14	15.31	1	7N	4E	SE30	29
Deep Creek	08-Nov-94	0.00	0.00	1391.00	473.00	420.00	124.00	251.00	284.00	98.00	56.00	3097.00	26.25	4.97	17.27	12.46	2	7N	4E	SE30	29
Deep Creek	08-Nov-94	0.00	630.00	771.00	399.00	256.00	67.00	153.00	150.00	55.00	36.00	2537.00	18.96	3.59	12.73	18.57	3	7N	4E	NW29	29
Deep Creek	08-Nov-94	0.00	0.00	305.00	383.00	289.00	111.00	221.00	177.00	105.00	40.00	1631.00	40.10	8.89	24.40	7.26	4	7N	4E	NW27	29
Deep Creek	08-Nov-94	1354.00	560.00	269.00	585.00	423.00	181.00	352.00	244.00	87.00	35.00	4090.00	21.98	2.98	14.57	22.58	5	7N	4E	NE27	29
Deep Creek	08-Nov-94	0.00	225.00	615.00	399.00	265.00	76.00	165.00	100.00	14.00	8.00	1867.00	19.44	1.18	14.19	17.06	6	7N	4E	SW26	29
Upper Deep Creek	05-Aug-91	0.00	0.00	654.00	438.00	567.00	189.00	397.00	401.00	81.00	29.00	2766.00	39.66	3.98	28.85	8.28	1	7N	5E	17D	3
Upper Deep Creek	05-Aug-91	0.00	0.00	603.00	406.00	245.00	100.00	225.00	241.00	45.00	38.00	1903.00	34.10	4.36	24.49	9.87	1	7N	5E	17D	3
Upper Deep Creek	05-Aug-91	0.00	728.00	421.00	870.00	718.00	227.00	525.00	511.00	90.00	54.00	4144.00	33.95	3.47	25.00	10.62	1	7N	5E	17D	3
Upper Deep Creek	05-Aug-91	0.00	0.00	1161.00	807.00	656.00	202.00	400.00	298.00	58.00	28.00	3610.00	27.31	2.38	19.34	11.91	2	7N	5E	17D	3
Upper Deep Creek	05-Aug-91	0.00	361.00	314.00	687.00	879.00	296.00	601.00	285.00	109.00	80.00	3712.00	39.63	5.09	26.56	8.08	3	7N	5E	17D	3
Upper Deep Creek	05-Aug-91	0.00	298.00	1107.00	436.00	352.00	102.00	254.00	226.00	34.00	27.00	2836.00	22.67	2.15	16.93	15.85	4	7N	5E	17D	3
Deep Creek (Private)	29-Apr-91	0.00	0.00	837.00	703.00	576.00	220.00	527.00	606.00	353.00	92.00	3914.00	45.94	11.37	28.95	6.26	1	7N	3E	SW28	29
Deep Creek (Private)	29-Apr-91	0.00	0.00	1393.00	947.00	655.00	233.00	570.00	887.00	542.00	120.00	5347.00	43.99	12.38	27.25	6.58	1	7N	3E	SW28	29
Deep Creek (Private)	29-Apr-91	760.00	0.00	1121.00	567.00	522.00	148.00	319.00	506.00	508.00	100.00	4552.00	34.75	13.36	18.12	10.09	1	7N	3E	SW28	29
Deep Creek (Private)	29-Apr-91	0.00	1724.00	677.00	837.00	799.00	298.00	748.00	588.00	536.00	135.00	6342.00	36.35	10.58	21.07	10.27	2	7N	3E	SW28	29
Deep Creek (Private)	29-Apr-91	0.00	214.00	1047.00	971.00	722.00	222.00	442.00	283.00	250.00	43.00	4204.00	29.73	7.21	17.25	10.59	2	7N	3E	SW28	29
Deep Creek (Private)	29-Apr-91	0.00	260.00	420.00	857.00	735.00	183.00	276.00	94.00	116.00	64.00	3005.00	24.39	5.99	12.31	10.97	2	7N	3E	SW28	29
Deep Creek (Private)	29-Apr-91	0.00	303.00	938.00	1097.00	727.00	208.00	485.00	326.00	418.00	165.00	4667.00	34.33	12.49	17.38	8.17	3	7N	3E	28	29
Deep Creek (Private)	29-Apr-91	0.00	596.00	1499.00	1048.00	815.00	298.00	659.00	333.00	391.00	196.00	5835.00	32.17	10.06	17.00	9.96	3	7N	3E	28	29
Deep Creek (Private)	29-Apr-91	0.00	0.00	1600.00	1263.00	931.00	284.00	521.00	166.00	506.00	159.00	5430.00	30.13	12.25	12.65	9.04	3	7N	3E	28	29
Deep Creek (Private)	29-Apr-91	0.00	0.00	730.00	1037.00	851.00	273.00	615.00	531.00	344.00	89.00	4470.00	41.43	9.69	25.64	6.81	4	7N	3E	28	29
Lump Gulch	15-Aug-89	0.00	0.00	925.00	808.00	545.00	246.00	669.00	832.00	441.00	118.00	4584.00	50.31	12.19	32.74	5.63	1				
Lump Gulch	15-Aug-89	0.00	233.00	1357.00	607.00	491.00	266.00	878.00	905.00	462.00	285.00	5484.00	50.98	13.62	32.51	5.67	2				

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76.2 mm Sieve (Grams)	50.8 mm Sieve (Grams)	25.4 mm Sieve (Grams)	12.7 mm Sieve (Grams)	6.3 mm Sieve (Grams)	4.76 mm Sieve (Grams)	2.38 mm Sieve (Grams)	0.85 mm Sieve (Grams)	0.074 mm Sieve (Grams)	<0.074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Lump Gulch	15-Aug-89	0.00	0.00	594.00	895.00	376.00	172.00	492.00	695.00	591.00	184.00	3699.00	53.36	19.38	29.68	4.31	2				
Lump Gulch	15-Aug-89	0.00	474.00	869.00	511.00	536.00	145.00	406.00	854.00	817.00	65.00	4687.00	49.01	18.82	27.10	5.73	3				
Lump Gulch	15-Aug-89	0.00	211.00	1531.00	741.00	639.00	234.00	696.00	1136.00	1347.00	130.00	6665.00	53.16	22.16	27.49	4.79	4				
Lump Gulch	15-Aug-89	0.00	0.00	1338.00	847.00	688.00	262.00	609.00	1032.00	1135.00	56.00	5967.00	51.85	19.96	27.50	4.98	4				
S. Fk. Quartz	15-Aug-87	0.00	0.00	833.00	781.00	664.00	298.00	1185.00	879.00	437.00	94.00	5171.00	55.95	10.27	39.91	5.30	3				
S. Fk. Quartz	15-Aug-87	0.00	0.00	848.00	901.00	408.00	90.00	374.00	415.00	458.00	372.00	3876.00	44.35	21.67	20.36	4.59	1				
S. Fk. Quartz	15-Aug-87	0.00	325.00	920.00	646.00	341.00	117.00	492.00	521.00	678.00	119.00	4159.00	46.33	19.16	24.36	6.12	2				
North Fork Quartz Creek	31-Jul-92	0.00	0.00	485.00	642.00	346.00	96.00	197.00	250.00	273.00	51.00	2340.00	37.05	13.85	19.10	7.12	1	8N	5W	NW 30	10
North Fork Quartz Creek	31-Jul-92	0.00	0.00	288.00	265.00	325.00	104.00	182.00	215.00	319.00	46.00	1744.00	49.66	20.93	22.76	4.64	2	8N	5W	NW 30	10
North Fork Quartz Creek	31-Jul-92	0.00	0.00	201.00	230.00	384.00	89.00	203.00	217.00	399.00	29.00	1752.00	53.48	24.43	23.97	3.90	3	8N	5W	NW 30	10
North Fork Quartz Creek	31-Jul-92	0.00	360.00	425.00	268.00	216.00	80.00	180.00	282.00	288.00	68.00	2167.00	41.44	16.43	21.32	7.52	4	8N	5W	NW 30	10
North Fork Quartz Creek	31-Jul-92	0.00	0.00	97.00	289.00	461.00	142.00	321.00	295.00	191.00	31.00	1827.00	53.64	12.15	33.72	4.60	5	8N	5W	NE 25	10
North Fork Quartz Creek	31-Jul-92	0.00	196.00	488.00	221.00	242.00	71.00	182.00	356.00	330.00	43.00	2129.00	46.12	17.52	25.27	6.29	6	8N	5W	NE 25	10
Quartz Creek	15-Aug-87	0.00	0.00	0.00	459.00	1355.00	458.00	1161.00	1262.00	1524.00	138.00	6357.00	71.46	26.14	38.12	2.43	1				
Kady Gulch	15-Aug-89	0.00	0.00	580.00	954.00	734.00	176.00	355.00	519.00	443.00	55.00	3816.00	40.57	13.05	22.90	6.35	1	7N	4W	6	26
Magpie	01-Sep-98	0.00	0.00	294.10	381.30	396.70	140.10	390.60	406.20	206.60	50.00	2265.60	52.68	11.33	35.17	5.11	1	11N	1E	21	29
Magpie	01-Sep-98	0.00	0.00	109.60	387.80	476.60	197.80	442.80	361.30	227.50	92.00	2295.40	57.57	13.92	35.03	4.05	2	11N	1E	21	29
Magpie	01-Sep-98	0.00	0.00	364.30	315.10	360.00	140.00	353.60	358.70	181.60	27.00	2110.30	50.75	9.88	34.23	5.78	3	11N	1E	21	29
Magpie	01-Sep-98	0.00	405.60	166.50	316.90	417.20	141.30	360.10	317.80	19.00	60.00	2204.40	40.75	3.58	30.75	8.84	4	11N	1E	21	29
Magpie	01-Sep-98	0.00	0.00	89.70	551.20	438.90	150.30	331.80	217.00	74.90	49.00	1902.80	43.25	6.51	28.84	6.30	5	11N	1E	21	29
Magpie	01-Sep-98	0.00	0.00	325.30	184.10	186.10	58.50	145.10	116.00	76.70	35.00	1126.80	38.28	9.91	23.17	7.78	6	11N	1E	21	29
Magpie	01-Sep-98	0.00	0.00	0.00	263.50	382.60	138.30	335.00	189.50	82.00	41.00	1431.90	54.88	8.59	36.63	4.63	7	11N	1E	21	29
(BLM)	28-Aug-91	0.00	310.00	697.00	817.00	827.00	244.00	497.00	527.00	309.00	79.00	4307.00	38.45	9.01	23.78	7.89	1	8N	3E	4B	3
(BLM)	28-Aug-91	0.00	194.00	808.00	1050.00	730.00	248.00	523.00	519.00	356.00	56.00	4494.00	37.87	9.17	23.19	8.09	2	8N	3E	4B	3
(BLM)	28-Aug-91	0.00	585.00	537.00	753.00	549.00	201.00	357.00	308.00	484.00	68.00	3842.00	36.91	14.37	17.31	8.42	3	8N	3E	4B	3
(BLM)	28-Aug-91	0.00	0.00	836.00	921.00	710.00	197.00	339.00	338.00	300.00	73.00	3714.00	33.58	10.04	18.23	8.20	4	8N	3E	4B	3
(BLM)	28-Aug-91	0.00	394.00	583.00	658.00	524.00	165.00	336.00	379.00	212.00	54.00	3305.00	34.67	8.05	21.63	9.46	5	8N	3E	4B	3
(BLM)	28-Aug-91	0.00	908.00	811.00	704.00	554.00	190.00	394.00	292.00	216.00	39.00	4108.00	27.53	6.21	16.70	13.58	6	8N	3E	4B	3
Dry Creek	17-Oct-89	0.00	0.00	854.00	620.00	497.00	205.00	501.00	560.00	260.00	51.00	3548.00	44.45	8.77	29.90	7.08	1	6N	4E	SW 29	3.16
Dry Creek	17-Oct-89	0.00	0.00	638.00	803.00	786.00	311.00	735.00	657.00	165.00	45.00	4150.00	46.34	5.06	33.78	6.83	2	6N	4E	SW 29	3.16
Dry Creek	17-Oct-89	1185.00	352.00	235.00	684.00	1032.00	358.00	589.00	236.00	185.00	75.00	4931.00	29.26	5.27	16.73	14.13	3	6N	4E	SW 29	3.16
Dry Creek	17-Oct-89	0.00	660.00	815.00	666.00	476.00	196.00	490.00	616.00	269.00	101.00	4289.00	38.98	8.63	25.79	9.07	4	6N	4E	SE 29	3.16
Dry Creek	17-Oct-89	0.00	0.00	430.00	825.00	582.00	207.00	465.00	587.00	303.00	57.00	3456.00	46.85	10.42	30.44	5.87	5	6N	4E	SE 29	3.16
Dry Creek	17-Oct-89	0.00	0.00	917.00	497.00	604.00	233.00	499.00	625.00	350.00	87.00	3812.00	47.06	11.46	29.49	6.18	5	6N	4E	SE 29	3.16
Dry Creek	17-Oct-89	0.00	0.00	651.00	668.00	532.00	231.00	504.00	657.00	423.00	64.00	3730.00	50.38	13.06	31.13	5.49	5	6N	4E	SE 29	3.16
Dry Creek	17-Oct-89	801.00	476.00	599.00	564.00	454.00	183.00	432.00	593.00	277.00	83.00	4462.00	35.14	8.07	22.97	12.02	6	6N	4E	SE 29	3.16
Dry Creek	17-Oct-89	0.00	151.00	504.00	785.00	830.00	312.00	625.00	560.00	210.00	65.00	4042.00	43.84	6.80	29.32	7.00	7	6N	4E	SE 29	3.16
Dry Creek	17-Oct-89	0.00	0.00	119.00	656.00	995.00	379.00	501.00	293.00	131.00	62.00	3136.00	43.56	6.15	25.32	6.21	8	6N	4E	SE 29	3.16
Gipsy Creek	01-Aug-91	0.00	0.00	528.00	584.00	692.00	176.00	344.00	351.00	274.00	92.00	3041.00	40.68	12.04	22.85	6.29	1	9N	4E	33A	24
Gipsy Creek	01-Aug-91	0.00	0.00	300.00	776.00	725.00	191.00	426.00	439.00	282.00	100.00	3239.00	44.40	11.79	26.71	5.54	2	9N	4E	33A	24
Gipsy Creek	01-Aug-91	0.00	0.00	989.00	715.00	478.00	148.00	334.00	427.00	394.00	136.00	3621.00	39.74	14.64	21.02	6.75	3	9N	4E	33A	24
Little Camas Creek (S.Fk.)	30-Jul-91	0.00	0.00	708.00	1207.00	780.00	228.00	454.00	450.00	281.00	69.00	4197.00	35.79	8.34	22.02	7.85	1	9N	4E	21B	11/22
Little Camas Creek (S.Fk.)	30-Jul-91	0.00	0.00	401.00	1147.00	846.00	329.00	454.00	452.00	245.00	66.00	3950.00	39.39	7.87	23.19	7.03	1	9N	4E	21B	11/22
Little Camas Creek (S.Fk.)	30-Jul-91	0.00	0.00	838.00	883.00	791.00	252.00	447.00	442.00	170.00	51.00	3874.00	35.16	5.70	22.95	8.62	1	9N	4E	21B	11/22
Little Camas Creek (S.Fk.)	30-Jul-91	0.00	447.00	419.00	713.00	772.00	300.00	519.00	344.00	206.00	51.00	3771.00	37.56	6.82	22.89	8.87	2	9N	4E	21B	11/22
Little Camas Creek (S.Fk.)	30-Jul-91	0.00	328.00	333.00	546.00	320.00	99.00	290.00	337.00	112.00	37.00	2402.00	36.43	6.28	26.10	9.45	3	9N	4E	21B	11/22
Little Camas Creek (S.Fk.)	30-Jul-91	0.00	0.00	510.00	693.00	643.00	175.00	348.00	381.00	229.00	46.00	3025.00	38.98	9.08	24.10	7.13	4	9N	4E	21B	11/22
Slough Creek (D-1)	19-Jul-94	0.00	0.00	312.00	618.00	523.00	195.00	301.00	217.00	116.00	59.00	2341.00	37.93	7.48	22.13	7.36	1				3
Slough Creek (D-1)	19-Jul-94	0.00	0.00	443.60	617.40	393.10	111.00	184.70	136.40	47.00	44.00	1977.20	26.46	4.50	16.24	10.39	2				3
Slough Creek (D-1)	19-Jul-94	0.00	0.00	525.20	568.00	426.90	141.10	233.40	126.50	57.90	132.00	2211.00	31.25	8.59	16.29	8.25	3				3
Elk Creek	19-Jul-94	0.00	0.00	438.10	888.60	468.10	97.10	113.70	83.30	90.90	63.00	2242.80	19.98	6.86	8.78	10.82	1				26
Elk Creek	19-Jul-94	0.00	0.00	555.10	418.80	338.80	91.40	181.30	149.30	86.40	46.00	1867.10	29.69	7.09	17.71	9.78	2				26
Elk Creek	19-Jul-94	0.00	0.00	482.90	715.10	596.90	208.30	397.60	235.90	93.80	81.00	2811.50	36.16	6.22	22.53	8.00	3				26
Elk Creek	19-Jul-94	0.00	0.00	80.00	907.60	502.70	144.90	211.60	174.90	121.50	98.00	2241.20	33.50	8.79	17.25	6.76	4				26
Elk Creek	19-Jul-94	0.00	0.00	714.00	559.60	550.20	185.70	342.50	289.60	173.30	81.00	2895.90	37.02	8.78	21.83	7.85	5				26

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Elk Creek	19-Jul-94	0.00	0.00	512.50	791.90	378.60	140.20	265.30	210.20	75.60	16.00	2390.30	29.59	3.83	19.89	10.50	6				26
Big Camas Creek	28-Jun-94	0.00	0.00	1926.00	1124.00	351.00	90.00	246.00	252.00	99.00	31.00	4119.00	17.43	3.16	12.09	16.41	1	9N	4E	NE 16	24
Big Camas Creek	28-Jun-94	0.00	0.00	1144.00	777.00	324.00	99.00	185.00	148.00	89.00	29.00	2795.00	19.68	4.22	11.91	14.61	2	9N	4E	NE 16	24
Big Camas Creek	28-Jun-94	0.00	345.00	1044.00	502.00	218.00	69.00	130.00	129.00	98.00	45.00	2580.00	18.26	5.54	10.04	17.10	3	9N	4E	NE 16	24
Big Camas Creek	28-Jun-94	0.00	732.00	912.00	577.00	300.00	106.00	231.00	274.00	111.00	27.00	3270.00	22.91	4.22	15.44	16.50	4	9N	4E	NE 16	24
Big Camas Creek	28-Jun-94	0.00	442.00	1426.00	562.00	259.00	69.00	161.00	140.00	48.00	22.00	3129.00	14.06	2.24	9.62	21.13	4	9N	4E	NE 16	24
Big Camas Creek	28-Jun-94	0.00	0.00	1147.00	715.00	369.00	104.00	180.00	229.00	178.00	21.00	2943.00	24.19	6.76	13.90	12.46	4	9N	4E	NE 16	24
Big Camas Creek	15-Jul-88	0.00	325.00	1644.00	1296.00	886.00	296.00	629.00	607.00	312.00	63.00	6058.00	31.48	6.19	20.40	10.59	1	9N	4E	16	24
Big Camas Creek	15-Jul-88	0.00	1505.00	952.00	846.00	748.00	311.00	647.00	606.00	326.00	57.00	5998.00	32.46	6.39	20.89	12.39	2	9N	4E	16	24
Big Camas Creek	15-Jul-88	0.00	2006.00	480.00	938.00	1037.00	317.00	642.00	740.00	434.00	68.00	6662.00	33.04	7.54	20.74	11.60	3	9N	4E	16	24
Big Camas Creek	15-Jul-88	0.00	1162.00	809.00	1059.00	856.00	265.00	506.00	338.00	106.00	52.00	5153.00	24.59	3.07	16.38	14.62	4	9N	4E	16	24
Big Camas Creek	15-Jul-88	0.00	988.00	938.00	1458.00	1057.00	344.00	639.00	525.00	268.00	83.00	6300.00	29.51	5.57	18.48	11.46	4	9N	4E	16	24
Big Camas Creek	15-Jul-88	0.00	1238.00	1040.00	1047.00	713.00	266.00	608.00	708.00	400.00	65.00	6085.00	33.64	7.64	21.63	11.13	4	9N	4E	16	24
Big Camas Creek	15-Jul-88	0.00	303.00	907.00	621.00	814.00	308.00	796.00	992.00	496.00	85.00	5322.00	50.30	10.92	33.60	6.05	5	9N	4E	16	24
Big Camas Creek	15-Jul-88	0.00	1622.00	906.00	1133.00	840.00	277.00	591.00	581.00	295.00	67.00	6312.00	28.69	5.74	18.57	13.27	6	9N	4E	16	24
Big Camas Creek	15-Jul-88	0.00	258.00	1005.00	1539.00	964.00	276.00	580.00	857.00	657.00	51.00	6187.00	39.13	11.44	23.23	7.40	7	9N	4E	16	24
Big Camas Creek	15-Jul-88	0.00	1680.00	1136.00	826.00	645.00	238.00	502.00	518.00	149.00	22.00	5716.00	25.00	2.99	17.84	16.73	8	9N	4E	16	24
Buffalo Creek	05-Aug-87	0.00	0.00	543.00	1117.00	983.00	237.00	605.00	615.00	657.00	101.00	4858.00	45.59	15.60	25.11	5.31	1				
Buffalo Creek	05-Aug-87	0.00	0.00	610.00	354.00	417.00	238.00	898.00	1150.00	1265.00	131.00	5063.00	72.72	27.57	40.45	2.63	2				
Buffalo Creek	05-Aug-87	0.00	0.00	1030.00	501.00	535.00	292.00	1104.00	1086.00	900.00	124.00	5572.00	62.92	18.38	39.30	4.02	3				
Prickly Pear Creek	15-Jun-93	0.00	0.00	929.00	827.00	543.00	154.00	283.00	503.00	581.00	27.00	3847.00	40.24	15.80	20.43	6.79	1	7N	3W	SE 14	25
Prickly Pear Creek	15-Jun-93	0.00	0.00	390.00	980.00	527.00	107.00	206.00	321.00	356.00	51.00	2938.00	35.43	13.85	17.94	6.84	2	7N	3W	SE 14	25
Prickly Pear Creek	15-Jun-93	0.00	852.00	1246.00	628.00	397.00	112.00	230.00	255.00	314.00	57.00	4091.00	23.66	9.07	11.86	14.69	3	7N	3W	SE 14	25
Prickly Pear Creek	15-Jun-93	0.00	274.00	1199.00	924.00	455.00	100.00	201.00	464.00	330.00	24.00	3971.00	28.18	8.91	16.75	11.12	4	7N	3W	SE 14	25
Prickly Pear Creek	15-Jun-93	0.00	0.00	1189.00	635.00	313.00	100.00	206.00	269.00	184.00	28.00	2924.00	26.92	7.25	16.24	11.87	5	7N	3W	SE 14	25
Prickly Pear Creek	15-Jun-93	0.00	0.00	912.00	593.00	235.00	50.00	120.00	226.00	315.00	49.00	2500.00	38.40	14.56	13.84	9.17	6	7N	3W	SE 14	25
Prickly Pear (pvt)	23-Aug-95	0.00	481.00	509.00	398.00	229.00	84.00	183.00	254.00	658.00	32.00	2828.00	42.82	24.40	15.45	6.81	1				
Prickly Pear (pvt)	23-Aug-95	0.00	261.00	1404.00	595.00	362.00	136.00	336.00	452.00	212.00	18.00	3776.00	30.56	6.09	20.87	12.11	1				
Prickly Pear (pvt)	23-Aug-95	593.00	406.00	482.00	556.00	376.00	131.00	300.00	231.00	97.00	27.00	3199.00	24.57	3.88	16.60	17.41	1				
Prickly Pear (pvt)	23-Aug-95	0.00	155.00	1065.00	867.00	398.00	117.00	263.00	464.00	419.00	9.00	3757.00	33.86	11.39	19.35	9.30	2				
Prickly Pear (pvt)	23-Aug-95	0.00	0.00	671.00	623.00	369.00	214.00	705.00	739.00	594.00	29.00	3994.00	58.36	15.60	37.41	4.72	3				
Prickly Pear (pvt)	23-Aug-95	0.00	594.00	794.00	529.00	450.00	188.00	562.00	558.00	439.00	31.00	4145.00	42.90	11.34	27.02	8.34	3				
Prickly Pear (pvt)	23-Aug-95	0.00	522.00	886.00	551.00	312.00	119.00	319.00	380.00	223.00	32.00	3344.00	32.09	7.63	20.90	11.73	3				
Prickly Pear (pvt)	23-Aug-95	0.00	0.00	746.00	606.00	317.00	106.00	339.00	497.00	298.00	34.00	2943.00	43.29	11.28	28.41	7.00	4				
Prickly Pear (pvt)	23-Aug-95	0.00	211.00	1189.00	653.00	228.00	79.00	167.00	350.00	382.00	8.00	3267.00	30.18	11.94	15.82	11.01	5				
Willow Creek	30-Jun-94	0.00	0.00	488.00	630.00	462.00	116.00	194.00	223.00	203.00	68.00	2384.00	33.72	11.37	17.49	7.63	1	13N	2W	SW 2	13
Willow Creek	30-Jun-94	0.00	0.00	185.00	681.00	670.00	181.00	304.00	224.00	203.00	78.00	2526.00	39.19	11.12	20.90	6.13	2	13N	2W	SW 2	13
Willow Creek	30-Jun-94	0.00	0.00	815.00	753.00	438.00	130.00	317.00	277.00	129.00	54.00	2913.00	31.14	6.28	20.39	9.82	2	13N	2W	SW 2	13
Willow Creek	30-Jun-94	0.00	0.00	563.00	789.00	493.00	137.00	310.00	283.00	180.00	44.00	2799.00	34.08	8.00	21.19	8.43	2	13N	2W	SW 2	13
Willow Creek	30-Jun-94	0.00	0.00	339.00	531.00	540.00	194.00	387.00	290.00	131.00	73.00	2485.00	43.26	8.21	27.24	6.46	3	13N	2W	NW 12	13
Willow Creek	30-Jun-94	0.00	523.00	992.00	380.00	325.00	103.00	285.00	221.00	79.00	58.00	3066.00	24.33	4.47	16.50	15.70	4	13N	2W	NW 12	13
Nevada Creek (pvt)	09-Sep-98	0.00	0.00	808.20	715.00	540.70	133.40	221.00	149.00	180.00	33.50	2780.80	25.78	7.68	13.31	10.73	1	12N	SW	29 E	29
Nevada Creek (pvt)	09-Sep-98	0.00	0.00	720.70	841.00	589.30	174.30	374.10	416.80	254.10	47.70	3418.00	37.07	8.83	23.14	7.87	2	12N	SW	29 E	29
Nevada Creek (pvt)	09-Sep-98	0.00	262.00	953.00	762.20	535.40	116.20	152.90	71.90	142.50	36.70	3042.90	17.43	5.89	7.72	14.89	3	12N	SW	29 E	29
Nevada Creek (pvt)	09-Sep-98	0.00	451.80	385.50	836.30	415.80	124.00	273.00	310.80	101.00	21.50	2919.70	28.44	4.20	20.00	11.94	4	12N	SW	29 E	29
Nevada Creek (pvt)	09-Sep-98	0.00	881.00	479.40	685.80	523.40	114.00	306.20	25.70	94.00	40.50	2950.00	12.89	4.56	4.47	19.34	5	12N	SW	29 E	29
Nevada Creek (pvt)	09-Sep-98	0.00	0.00	689.40	679.30	462.10	157.90	306.80	274.80	151.00	10.90	2732.20	32.99	5.93	21.29	9.64	6	12N	SW	29 E	29
Chicken Creek (D-4)	02-Sep-98	0.00	0.00	347.80	863.00	606.20	121.50	180.40	125.00	95.00	40.90	2379.80	23.65	5.71	12.83	9.93	1	13N	10W	36 S	3
Chicken Creek (D-4)	02-Sep-98	0.00	0.00	182.60	541.80	563.40	183.80	366.60	225.30	83.40	35.70	2182.60	41.00	5.46	27.12	6.97	2	13N	10W	36 S	3
Chicken Creek (D-4)	02-Sep-98	0.00	0.00	156.30	856.80	735.70	198.80	304.70	224.00	88.50	15.80	2580.60	32.23	4.04	20.49	8.31	3	13N	10W	36 S	3
Chicken Creek (D-4)	02-Sep-98	0.00	0.00	430.00	533.50	477.30	114.90	224.40	188.60	136.90	32.00	2137.60	32.60	7.90	19.32	8.50	4	13N	10W	36 S	3
Chicken Creek (D-4)	02-Sep-98	0.00	0.00	283.30	862.70	508.80	146.70	237.50	184.80	178.10	24.20	2426.10	31.79	8.34	17.41	8.32	4	13N	10W	36 S	3
Chicken Creek (D-4)	02-Sep-98	0.00	0.00	46.60	772.00	684.00	180.30	282.00	131.00	162.60	38.10	2296.60	34.57	8.74	17.98	6.98	5	13N	10W	36 S	3
Deer Creek (D-4)	26-Aug-98	0.00	0.00	79.70	653.00	529.30	176.40	285.30	142.70	22.30	41.50	1930.20	34.62	3.31	22.17	7.88	1	13N	10W	26 s 35 n	11
Deer Creek (D-4)	26-Aug-98	0.00	0.00	73.00	632.90	697.80	177.90	308.00	218.70	111.00	55.90	2275.20	38.30	7.34	23.15	6.43	1	13N	10W	26 s 35 n	11
Deer Creek (D-4)	26-Aug-98	0.00	218.80	596.70	597.60	460.80	138.60	253.30	147.80	48.10	43.80	2505.50	25.21	3.67	16.01	12.50	2	13N	10W	26 s 35 n	11

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Deer Creek (D-4)	26-Aug-98	0.00	0.00	346.20	794.00	763.00	215.60	314.60	161.30	26.00	38.20	2658.90	28.42	2.41	17.90	9.62	3	13N	10W	26 s/ 35 n	11
Deer Creek (D-4)	26-Aug-98	0.00	425.00	35.50	420.40	454.10	119.00	225.30	133.60	41.20	42.90	1897.00	29.63	4.43	18.92	10.93	4	13N	10W	26 s/ 35 n	11
Deer Creek (D-4)	26-Aug-98	0.00	0.00	270.20	568.40	435.80	107.80	146.30	68.00	51.00	55.10	1702.60	25.15	6.23	12.59	9.44	5	13N	10W	26 s/ 35 n	11
Huckleberry Creek	16-Sep-98	0.00	0.00	42.30	327.40	420.00	159.60	363.90	329.20	188.40	39.97	1880.77	58.01	12.14	36.85	4.20	1	12N	SW	15 e	3
Huckleberry Creek	16-Sep-98	0.00	0.00	75.30	645.50	484.20	146.40	272.00	207.50	124.00	44.60	1999.50	39.73	8.43	23.98	6.43	2	12N	SW	15 e	3
Huckleberry Creek	16-Sep-98	0.00	0.00	155.30	463.40	410.40	130.40	257.70	171.00	61.50	38.50	1688.20	39.04	5.92	25.39	7.12	3	12N	SW	15 e	3
Huckleberry Creek	16-Sep-98	0.00	0.00	513.30	689.80	507.30	153.90	267.20	163.80	101.60	38.50	2435.50	29.77	5.76	17.70	9.65	4	12N	SW	15 e	3
Huckleberry Creek	16-Sep-98	0.00	0.00	687.50	622.50	482.90	121.80	201.00	95.40	33.10	20.80	2265.00	20.84	2.38	13.09	13.18	4	12N	SW	15 e	3
Huckleberry Creek	16-Sep-98	0.00	0.00	29.00	759.00	728.50	183.50	227.00	93.00	63.70	40.50	2124.20	28.61	4.91	15.06	8.11	5	12N	SW	15 e	3
Chimney Creek (D-4)	30-Jul-98	0.00	0.00	170.00	376.70	448.00	140.80	246.00	183.30	222.90	92.00	1879.70	47.08	16.75	22.84	4.69	1	13N	10W	33 nw	3
Chimney Creek (D-4)	30-Jul-98	0.00	0.00	23.30	376.20	361.50	95.30	198.00	158.00	162.00	71.30	1445.60	47.36	16.14	24.63	4.39	2	13N	10W	33 nw	3
Chimney Creek (D-4)	30-Jul-98	0.00	0.00	35.40	197.20	532.50	188.20	330.80	241.30	261.40	82.40	1869.20	59.07	18.39	30.61	3.41	3	13N	10W	33 nw	3
Chimney Creek (D-4)	30-Jul-98	0.00	0.00	0.00	253.80	658.60	194.70	251.30	124.20	117.00	50.10	1649.70	44.69	10.13	22.76	5.10	4	13N	10W	33 nw	3
Chimney Creek (D-4)	30-Jul-98	0.00	0.00	48.70	325.00	420.00	173.00	285.00	194.00	149.00	62.70	1657.40	52.11	12.77	28.90	4.55	5	13N	10W	33 nw	3
Chimney Creek (D-4)	30-Jul-98	0.00	0.00	270.40	407.70	290.70	87.60	156.50	101.90	76.00	80.00	1470.80	34.13	10.61	17.57	7.26	6	13N	10 W	33 nw	3
Madison Creek (D-4)	14-Sep-98	0.00	0.00	457.30	968.60	535.50	97.50	147.10	197.40	341.00	60.00	2804.40	30.06	14.30	12.28	7.67	1	12N	9W	2	26
Madison Creek (D-4)	14-Sep-98	0.00	0.00	783.70	877.50	386.30	91.50	146.80	204.40	177.60	58.80	2726.60	24.91	8.67	12.88	10.53	1	12N	9W	2	26
Madison Creek (D-4)	14-Sep-98	0.00	0.00	613.20	1062.20	737.00	191.00	301.50	227.20	52.30	32.60	3217.00	25.01	2.64	16.43	10.93	2	12N	9W	2	26
Madison Creek (D-4)	14-Sep-98	0.00	0.00	235.40	637.80	461.70	184.80	311.50	296.80	188.80	23.30	2340.10	42.96	9.06	25.99	6.58	3	12N	9W	2	26
Madison Creek (D-4)	14-Sep-98	0.00	0.00	466.60	1076.00	533.10	125.20	197.90	208.50	83.60	14.90	2705.80	23.29	3.64	15.02	11.14	4	12N	9W	2	26
Madison Creek (D-4)	14-Sep-98	0.00	0.00	414.60	803.30	396.40	116.70	182.40	185.00	133.00	35.80	2267.20	28.80	7.45	16.21	9.35	5	12N	9W	2	26
Madison Gulch (D-4)	01-Sep-97	0.00	284.00	510.00	636.00	226.00	39.00	42.00	18.00	13.00	51.00	1819.00	8.96	3.52	3.30	19.14	1				
Madison Gulch (D-4)	01-Sep-97	0.00	0.00	480.00	378.00	313.00	71.00	90.00	38.00	5.00	12.00	1387.00	15.57	1.23	9.23	15.23	2				
Madison Gulch (D-4)	01-Sep-97	0.00	397.00	385.00	747.00	360.00	5.00	123.00	146.00	103.00	66.00	2332.00	19.00	7.25	11.54	13.10	3				
Madison Gulch (D-4)	01-Sep-97	0.00	451.00	599.00	782.00	327.00	65.00	89.00	128.00	116.00	30.00	2587.00	16.54	5.64	8.39	16.11	4				
Madison Gulch (D-4)	01-Sep-97	0.00	0.00	577.00	579.00	296.00	67.00	96.00	84.00	59.00	40.00	1798.00	19.24	5.51	10.01	12.72	4				
Madison Gulch (D-4)	01-Sep-97	0.00	0.00	822.00	786.00	331.00	77.00	114.00	102.00	54.00	42.00	2328.00	16.71	4.12	9.28	14.34	5				
Jefferson Creek	11-Jul-94	0.00	0.00	19.00	698.00	766.00	168.00	254.00	444.00	417.00	28.00	2794.00	46.92	15.93	24.98	4.60	1	12N	9W	NE 2	3
Jefferson Creek	11-Jul-94	0.00	0.00	17.00	514.00	843.00	229.00	366.00	536.00	560.00	42.00	3107.00	55.78	19.38	29.03	3.65	1	12N	9W	NE 2	3
Jefferson Creek	11-Jul-94	0.00	256.00	265.00	412.00	411.00	91.00	152.00	241.00	338.00	58.00	2224.00	39.57	17.81	17.67	6.55	2	12N	9W	NE 2	3
Jefferson Creek	11-Jul-94	0.00	0.00	103.00	525.00	710.00	218.00	456.00	634.00	371.00	63.00	3080.00	56.56	14.09	35.39	4.02	3	12N	9W	NE 2	3
Jefferson Creek	11-Jul-94	0.00	190.00	515.00	837.00	441.00	107.00	207.00	393.00	361.00	33.00	3084.00	35.70	12.78	19.46	7.89	4	12N	9W	NE 2	3
Jefferson Creek	11-Jul-94	0.00	0.00	373.00	756.00	562.00	144.00	246.00	495.00	489.00	36.00	3101.00	45.47	16.93	23.90	5.27	4	12N	9W	NE 2	3
Buffalo Gulch (D-4)	08-Sep-97	0.00	0.00	221.00	784.00	550.00	119.00	180.00	144.00	188.00	19.00	2205.00	29.48	9.39	14.69	8.23	1				3
Buffalo Gulch (D-4)	08-Sep-97	0.00	0.00	292.00	953.00	773.00	200.00	213.00	124.00	178.00	59.00	2792.00	27.72	8.49	12.07	8.43	2				3
Buffalo Gulch (D-4)	08-Sep-97	0.00	0.00	911.00	549.00	374.00	106.00	161.00	130.00	157.00	47.00	2445.00	24.99	8.75	11.90	11.36	3				3
Buffalo Gulch (D-4)	08-Sep-97	0.00	0.00	540.00	523.00	250.00	63.00	113.00	89.00	153.00	81.00	1812.00	27.54	12.91	11.15	8.99	4				3
Buffalo Gulch (D-4)	08-Sep-97	0.00	278.00	904.00	601.00	374.00	99.00	151.00	93.00	126.00	39.00	2665.00	19.06	6.19	9.16	15.12	5				3
Buffalo Gulch (D-4)	08-Sep-97	0.00	435.00	545.00	479.00	370.00	104.00	168.00	142.00	273.00	45.00	2561.00	28.58	12.42	12.10	10.98	6				3
West Fork Willow	05-Sep-97	0.00	298.00	575.00	892.00	328.00	97.00	166.00	183.00	201.00	22.00	2762.00	24.22	8.07	12.64	12.32	1				
West Fork Willow	05-Sep-97	0.00	0.00	627.00	699.00	360.00	100.00	187.00	228.00	237.00	13.00	2451.00	31.21	10.20	16.93	9.23	2				
West Fork Willow	05-Sep-97	0.00	0.00	874.00	708.00	362.00	106.00	195.00	229.00	351.00	33.00	2868.00	32.22	13.74	14.78	8.79	3				
West Fork Willow	05-Sep-97	0.00	0.00	34.00	472.00	499.00	180.00	299.00	237.00	270.00	41.00	2032.00	50.54	15.31	26.38	4.59	4				
West Fork Willow	05-Sep-97	0.00	247.00	482.00	632.00	408.00	135.00	236.00	201.00	160.00	42.00	2544.00	30.42	7.94	17.18	10.29	5				
West Fork Willow	05-Sep-97	0.00	0.00	540.00	910.00	610.00	181.00	245.00	174.00	131.00	39.00	2830.00	27.21	6.01	14.81	9.93	6				
Blackfoot- NevOg	10-Nov-97	0.00	0.00	865.00	1602.00	448.00	94.00	138.00	125.00	1043.00	20.00	4335.00	32.76	24.52	6.07	6.95	1				32
Blackfoot- NevOg	10-Nov-97	0.00	0.00	1238.00	1544.00	760.00	173.00	270.00	225.00	1070.00	16.00	5296.00	33.12	20.51	9.35	7.45	1				32
Blackfoot- NevOg	10-Nov-97	0.00	0.00	1249.00	1323.00	283.00	73.00	142.00	153.00	673.00	19.00	3915.00	27.08	17.68	7.54	9.66	1				32
Blackfoot- NevOg	10-Nov-97	0.00	522.00	1155.00	849.00	668.00	250.00	459.00	517.00	840.00	23.00	5283.00	39.54	16.34	18.47	7.89	2				32
Blackfoot- NevOg	10-Nov-97	0.00	0.00	306.00	1413.00	1056.00	354.00	654.00	604.00	1034.00	25.00	5446.00	49.05	19.45	23.10	4.77	3				32
Blackfoot- NevOg	10-Nov-97	0.00	0.00	1789.00	1191.00	745.00	215.00	200.00	58.00	720.00	29.00	4957.00	24.85	15.11	5.41	10.60	4				32
Blackfoot-Helmville	15-Nov-97	0.00	0.00	1225.00	1534.00	748.00	156.00	229.00	153.00	586.00	30.00	4661.00	24.76	13.22	8.20	10.03	1				32
Blackfoot-Helmville	15-Nov-97	0.00	0.00	908.00	2058.00	1085.00	174.00	274.00	140.00	1101.00	33.00	5773.00	29.83	19.64	7.17	7.42	2				32
Blackfoot-Helmville	15-Nov-97	0.00	0.00	1002.00	1465.00	709.00	172.00	294.00	213.00	818.00	33.00	4706.00	32.51	18.08	10.77	7.68	3				32
Blackfoot-Helmville	15-Nov-97	0.00	0.00	1624.00	923.00	405.00	117.00	198.00	218.00	532.00	25.00	4042.00	26.97	13.78	10.29	10.77	4				32
Blackfoot-Helmville	15-Nov-97	0.00	345.00	1083.00	1525.00	792.00	228.00	407.00	379.00	938.00	23.00	5720.00	34.53	16.80	13.74	8.07	4				32

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Blackfoot-Helmville	15-Nov-97	0.00	234.00	1185.00	1596.00	535.00	120.00	137.00	122.00	657.00	53.00	4639.00	23.47	15.31	5.58	10.59	4				32
Blackfoot-Dalton	15-Sep-96	0.00	1699.00	1041.00	585.00	419.00	174.00	336.00	214.00	215.00	25.00	4708.00	20.48	5.10	11.68	19.94	1				32
Blackfoot-Dalton	15-Sep-96	0.00	892.00	1223.00	1063.00	978.00	328.00	485.00	76.00	544.00	61.00	5650.00	26.44	10.71	9.93	12.09	1				32
Blackfoot-Dalton	15-Sep-96	0.00	0.00	1602.00	1323.00	1038.00	285.00	229.00	32.00	645.00	101.00	5255.00	24.59	14.20	4.97	9.87	1				32
Blackfoot-Dalton	15-Sep-96	0.00	993.00	889.00	1074.00	472.00	100.00	80.00	5.00	125.00	36.00	3784.00	9.14	4.25	2.25	21.92	2				32
Blackfoot-Dalton	15-Sep-96	0.00	980.00	1005.00	1409.00	635.00	102.00	81.00	143.00	653.00	103.00	5111.00	21.17	14.79	4.38	12.26	3				32
Blackfoot-Dalton	15-Sep-96	0.00	434.00	1098.00	794.00	751.00	239.00	436.00	566.00	551.00	62.00	4931.00	37.60	12.43	20.32	8.30	4				32
Blackfoot-Dalton	10-Nov-97	0.00	1250.00	1699.00	571.00	308.00	82.00	170.00	71.00	217.00	18.00	4386.00	12.72	5.36	5.49	23.86	1				32
Blackfoot-Dalton	10-Nov-97	0.00	125.00	1650.00	861.00	681.00	211.00	499.00	714.00	614.00	22.00	5377.00	38.31	11.83	22.56	8.32	1				32
Blackfoot-Dalton	10-Nov-97	0.00	294.00	1134.00	1012.00	562.00	159.00	332.00	472.00	469.00	26.00	4460.00	32.69	11.10	18.03	9.56	1				32
Blackfoot-Dalton	10-Nov-97	0.00	0.00	2285.00	1462.00	275.00	29.00	33.00	39.00	301.00	108.00	4532.00	11.25	9.02	1.59	16.73	2				32
Blackfoot-Dalton	10-Nov-97	0.00	0.00	653.00	1046.00	822.00	244.00	405.00	673.00	1043.00	59.00	4855.00	48.92	23.24	21.76	4.64	3				32
Blackfoot-Dalton	10-Nov-97	0.00	727.00	1016.00	692.00	590.00	210.00	352.00	360.00	523.00	17.00	4487.00	32.58	12.03	15.87	10.63	4				32
Wasson Creek	01-Oct-90	0.00	211.00	741.00	688.00	548.00	134.00	208.00	280.00	202.00	58.00	3070.00	28.73	8.47	15.90	10.16	1	13N	10W	9	6
Wasson Creek	01-Oct-90	0.00	0.00	340.00	1179.00	1055.00	319.00	531.00	827.00	517.00	51.00	4819.00	46.59	11.79	28.18	5.42	1	13N	10W	9	6
Wasson Creek	01-Oct-90	0.00	0.00	552.00	1167.00	1041.00	352.00	604.00	786.00	553.00	99.00	5164.00	46.55	12.63	26.92	5.50	1	13N	10W	9	6
Wasson Creek	15-Jul-93	0.00	0.00	508.00	746.00	556.00	156.00	262.00	444.00	304.00	49.00	3025.00	40.17	11.67	23.34	6.62	1	13N	10W	SE9	6
Wasson Creek	15-Jul-93	0.00	297.00	776.00	509.00	500.00	124.00	238.00	409.00	224.00	38.00	3115.00	33.16	8.41	20.77	9.76	1	13N	10W	SE9	6
Wasson Creek	15-Jul-93	0.00	0.00	647.00	744.00	546.00	162.00	284.00	457.00	201.00	28.00	3069.00	36.88	7.46	24.14	8.02	2	13N	10W	SE9	6
Wasson Creek	15-Jul-93	0.00	0.00	701.00	923.00	423.00	136.00	264.00	445.00	211.00	44.00	3147.00	34.95	8.10	22.53	8.41	2	13N	10W	SE9	6
Wasson Creek	15-Jul-93	0.00	0.00	294.00	705.00	484.00	167.00	348.00	557.00	281.00	43.00	2879.00	48.49	11.25	31.43	5.44	3	13N	10W	SE9	6
Wasson Creek	15-Jul-93	0.00	0.00	493.00	932.00	559.00	157.00	283.00	372.00	146.00	22.00	2964.00	33.06	5.67	22.10	8.73	4	13N	10W	SE9	6
Nevada Creek	01-Sep-90	0.00	0.00	1028.00	1153.00	865.00	302.00	447.00	588.00	388.00	102.00	4873.00	37.49	10.06	21.24	7.50	1				29
Nevada Creek	01-Sep-90	1562.00	405.00	472.00	907.00	722.00	194.00	251.00	166.00	31.00	30.00	4740.00	14.18	1.29	8.80	25.31	2				29
Nevada Creek	01-Sep-90	0.00	519.00	1348.00	862.00	572.00	186.00	311.00	469.00	339.00	58.00	4664.00	29.22	8.51	16.72	11.46	3				29
Nevada Creek	01-Sep-90	0.00	0.00	1722.00	1076.00	665.00	198.00	386.00	520.00	148.00	43.00	4758.00	27.22	4.01	19.04	11.84	4				29
Nevada Creek	01-Sep-90	0.00	0.00	1080.00	887.00	700.00	277.00	566.00	497.00	172.00	72.00	4251.00	37.26	5.74	25.01	8.68	5				29
Nevada Creek	01-Sep-90	805.00	559.00	1016.00	650.00	475.00	180.00	279.00	392.00	152.00	60.00	4568.00	23.27	4.64	14.69	17.80	6				29
Clear Creek	05-Sep-90	0.00	0.00	788.00	1866.00	918.00	249.00	362.00	345.00	417.00	281.00	5226.00	31.65	13.36	13.53	7.09	1				3
Clear Creek	05-Sep-90	0.00	0.00	40.00	767.00	992.00	285.00	397.00	400.00	1014.00	267.00	4162.00	56.78	30.78	19.15	2.72	1				3
Clear Creek	05-Sep-90	0.00	0.00	248.00	1208.00	1395.00	374.00	529.00	520.00	912.00	193.00	5379.00	47.00	20.54	19.50	4.28	1				3
Clear Creek	05-Sep-90	0.00	0.00	256.00	713.00	714.00	192.00	336.00	341.00	371.00	187.00	3110.00	45.88	17.94	21.77	4.47	2				3
Clear Creek	05-Sep-90	0.00	0.00	204.00	543.00	865.00	291.00	454.00	551.00	390.00	137.00	3435.00	53.07	15.34	29.26	4.14	2				3
Clear Creek	05-Sep-90	0.00	0.00	166.00	1239.00	822.00	215.00	313.00	318.00	385.00	169.00	3627.00	38.60	15.27	17.40	5.48	2				3
Clear Creek	05-Sep-90	0.00	0.00	167.00	890.00	1430.00	405.00	497.00	287.00	420.00	174.00	4270.00	41.76	13.91	18.36	5.17	3				3
Clear Creek	05-Sep-90	0.00	0.00	128.00	1218.00	1147.00	314.00	472.00	435.00	418.00	200.00	4332.00	42.45	14.27	20.94	5.04	3				3
Clear Creek	05-Sep-90	0.00	362.00	608.00	1022.00	795.00	250.00	426.00	431.00	636.00	295.00	4825.00	42.24	19.30	17.76	5.51	3				3
Gleason Creek	10-Sep-90	0.00	0.00	499.00	471.00	795.00	335.00	478.00	448.00	213.00	45.00	3284.00	46.25	7.86	28.20	6.37	1				
Gleason Creek	10-Sep-90	615.00	309.00	842.00	811.00	676.00	272.00	438.00	504.00	241.00	68.00	4776.00	31.89	6.47	19.72	12.02	2				
Gleason Creek	10-Sep-90	0.00	532.00	272.00	970.00	895.00	250.00	243.00	358.00	474.00	105.00	4219.00	36.74	13.72	16.85	7.36	3				
Gleason Creek	10-Sep-90	0.00	0.00	890.00	849.00	907.00	322.00	537.00	462.00	156.00	92.00	4215.00	37.22	5.88	23.70	8.10	3				
Gleason Creek	10-Sep-90	0.00	0.00	492.00	1185.00	812.00	246.00	380.00	584.00	668.00	81.00	4448.00	44.04	16.84	21.67	5.42	3				
Gleason Creek	10-Sep-90	0.00	0.00	990.00	1214.00	900.00	307.00	390.00	318.00	62.00	26.00	4207.00	26.22	2.09	16.83	11.43	4				
Washington Creek	20-Aug-92	0.00	863.00	497.00	519.00	446.00	125.00	224.00	244.00	114.00	6.00	3038.00	23.47	3.95	15.40	16.66	1	12N	SW	NW8	3
Washington Creek	20-Aug-92	0.00	0.00	471.00	728.00	537.00	174.00	371.00	354.00	152.00	38.00	2845.00	38.98	7.03	25.83	7.58	2	12N	SW	S	3
Washington Creek	20-Aug-92	0.00	0.00	145.00	493.00	665.00	269.00	506.00	353.00	197.00	38.00	2666.00	51.13	8.81	32.22	5.36	2	12N	SW	S	3
Washington Creek	20-Aug-92	0.00	235.00	815.00	759.00	502.00	155.00	339.00	342.00	134.00	32.00	3313.00	30.24	5.01	20.56	11.06	2	12N	SW	S	3
Washington Creek	20-Aug-92	0.00	0.00	372.00	977.00	511.00	103.00	239.00	274.00	76.00	28.00	2580.00	27.91	4.03	19.88	9.64	3	12N	SW	NW8	3
Washington Creek	20-Aug-92	0.00	0.00	635.00	220.00	227.00	66.00	128.00	153.00	140.00	67.00	1636.00	33.86	12.65	17.18	8.45	4	12N	SW	NW8	3
Sheldon Gulch	16-Jul-92	0.00	189.00	223.00	913.00	595.00	165.00	241.00	325.00	439.00	105.00	3295.00	41.73	16.51	20.21	5.84	1	13N	9W	SE33	26
Sheldon Gulch	16-Jul-92	0.00	0.00	461.00	1008.00	602.00	155.00	301.00	245.00	315.00	51.00	3138.00	34.00	11.66	17.40	7.59	2	13N	9W	SE 33	26
Sheldon Gulch	16-Jul-92	0.00	0.00	58.00	406.00	697.00	228.00	341.00	253.00	457.00	89.00	2539.00	54.27	21.90	23.40	3.62	3	13N	9W	SE 33	26
Sheldon Gulch	16-Jul-92	0.00	0.00	92.00	455.00	1034.00	293.00	391.00	319.00	426.00	98.00	3108.00	49.13	16.86	22.84	4.26	4	13N	9W	SE 33	26
Sheldon Gulch	16-Jul-92	0.00	0.00	125.00	636.00	975.00	259.00	484.00	448.00	507.00	65.00	3499.00	50.39	16.35	26.64	4.42	5	13N	9W	SE 33	26
Sheldon Gulch	16-Jul-92	0.00	0.00	428.00	997.00	754.00	183.00	284.00	225.00	136.00	71.00	3078.00	29.21	6.73	16.54	8.64	6	13N	9W	SE 33	26
Buffalo Gulch	14-Jul-92	0.00	1128.00	1041.00	1122.00	440.00	131.00	213.00	128.00	124.00	42.00	4369.00	14.60	3.80	7.80	20.02	1	13N	9W	SW 33	3

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Buffalo Gulch	14-Jul-92	0.00	347.00	808.00	801.00	579.00	141.00	226.00	161.00	294.00	42.00	3399.00	25.42	9.89	11.39	11.45	2	13N	9W	SW 33	3
Buffalo Gulch	14-Jul-92	0.00	0.00	522.00	1400.00	920.00	107.00	75.00	22.00	21.00	108.00	3175.00	10.49	4.06	3.06	12.48	3	13N	9W	SW 33	3
Buffalo Gulch	14-Jul-92	0.00	1133.00	603.00	820.00	636.00	126.00	163.00	85.00	66.00	59.00	3691.00	13.52	3.39	6.72	19.51	4	13N	9W	SW 33	3
Buffalo Gulch	14-Jul-92	0.00	0.00	651.00	1086.00	905.00	160.00	203.00	85.00	32.00	52.00	3174.00	16.76	2.65	9.07	12.37	5	13N	9W	SW 33	3
Buffalo Gulch	14-Jul-92	0.00	0.00	554.00	640.00	651.00	158.00	243.00	215.00	229.00	74.00	2764.00	33.25	10.96	16.57	7.67	6	13N	9W	SW 33	3
Shingle Mill Creek	03-Aug-92	0.00	0.00	394.00	748.00	762.00	227.00	267.00	65.00	20.00	60.00	2543.00	25.13	3.15	13.06	10.18	1	12N	SW	NE 33	3
Shingle Mill Creek	03-Aug-92	0.00	0.00	160.00	897.00	761.00	165.00	215.00	102.00	51.00	80.00	2431.00	25.22	5.39	13.04	8.64	2	12N	SW	NE 33	3
Shingle Mill Creek	03-Aug-92	0.00	0.00	157.00	699.00	923.00	255.00	302.00	74.00	36.00	60.00	2506.00	29.01	3.83	15.00	8.42	3	12N	SW	NE 33	3
Shingle Mill Creek	03-Aug-92	0.00	295.00	337.00	798.00	749.00	200.00	198.00	53.00	10.00	49.00	2689.00	18.97	2.19	9.33	13.21	4	12N	SW	NE 33	3
Shingle Mill Creek	03-Aug-92	0.00	0.00	158.00	753.00	879.00	213.00	292.00	156.00	40.00	66.00	2557.00	30.00	4.15	17.52	8.06	5	12N	SW	NE 33	3
Shingle Mill Creek	03-Aug-92	0.00	0.00	303.00	968.00	1076.00	240.00	302.00	113.00	16.00	81.00	3099.00	24.27	3.13	13.39	9.41	6	12N	SW	NE 33	3
Wilson Creek	23-Jun-93	0.00	483.00	412.00	579.00	449.00	126.00	231.00	375.00	243.00	22.00	2920.00	34.14	9.08	20.75	9.76	1	13N	10W	SW 16	3
Wilson Creek	23-Jun-93	0.00	187.00	866.00	1002.00	574.00	132.00	208.00	259.00	236.00	44.00	3508.00	25.06	7.98	13.31	11.16	2	13N	10W	SE 17	3
Wilson Creek	23-Jun-93	0.00	227.00	843.00	778.00	428.00	115.00	216.00	359.00	155.00	15.00	3136.00	27.42	5.42	18.34	11.81	3	13N	10W	SE 17	3
Wilson Creek	23-Jun-93	0.00	235.00	512.00	987.00	426.00	85.00	149.00	254.00	205.00	45.00	2898.00	25.47	8.63	13.91	10.66	3	13N	10W	SE 17	3
Wilson Creek	23-Jun-93	0.00	0.00	789.00	1128.00	577.00	141.00	271.00	473.00	255.00	21.00	3655.00	31.76	7.55	20.36	9.03	3	13N	10W	SE 17	3
Wilson Creek	23-Jun-93	0.00	302.00	557.00	782.00	468.00	106.00	216.00	350.00	152.00	13.00	2946.00	28.41	5.60	19.21	11.15	4	13N	10W	SE 17	3
Dry Creek (D4)	19-Jul-93	0.00	240.00	1220.00	1054.00	581.00	101.00	100.00	69.00	46.00	9.00	3420.00	9.50	1.61	4.94	19.28	1	15N	10W	17	28
Dry Creek (D4)	19-Jul-93	0.00	684.00	851.00	814.00	409.00	128.00	208.00	322.00	158.00	13.00	3587.00	23.11	4.77	14.78	15.07	2	15N	10W	17	28
Dry Creek (D4)	19-Jul-93	0.00	0.00	1244.00	920.00	393.00	49.00	50.00	109.00	138.00	41.00	2944.00	13.15	6.08	5.40	15.57	3	15N	10W	17	28
Dry Creek (D4)	19-Jul-93	0.00	394.00	1163.00	1085.00	252.00	23.00	23.00	37.00	63.00	29.00	2979.00	5.87	3.09	2.01	21.96	3	15N	10W	17	28
Dry Creek (D4)	19-Jul-93	0.00	392.00	1224.00	777.00	401.00	117.00	178.00	113.00	56.00	36.00	3294.00	15.18	2.79	8.83	18.41	4	15N	10W	SE 17	28
Dry Creek (D4)	19-Jul-93	0.00	0.00	976.00	835.00	520.00	136.00	248.00	269.00	93.00	15.00	3092.00	24.61	3.49	16.72	12.23	5	15N	10W	SE 17	28
S.24)	29-Jul-94	0.00	0.00	201.00	386.00	480.00	131.00	241.00	287.00	357.00	100.00	2183.00	51.12	20.93	24.19	3.98	1	15N	11W		
S.24)	29-Jul-94	0.00	0.00	182.00	465.00	515.00	149.00	273.00	294.00	488.00	90.00	2456.00	52.59	23.53	23.09	3.78	1	15N	11W		
S.24)	29-Jul-94	0.00	0.00	359.00	710.00	443.00	127.00	253.00	232.00	222.00	59.00	2405.00	37.13	11.68	20.17	7.01	2	15N	11W		
S.24)	29-Jul-94	0.00	0.00	428.00	456.00	406.00	116.00	232.00	247.00	322.00	80.00	2287.00	43.59	17.58	20.94	5.54	2	15N	11W		
S.24)	29-Jul-94	0.00	0.00	606.00	854.00	370.00	122.00	236.00	328.00	336.00	89.00	2941.00	37.78	14.45	19.19	6.88	3	15N	11W		
S.24)	29-Jul-94	0.00	0.00	129.00	733.00	371.00	107.00	239.00	369.00	377.00	65.00	2390.00	48.41	18.49	25.44	4.56	3	15N	11W		
Dry Creek (D4)	09-Aug-95	0.00	476.00	1166.00	963.00	438.00	137.00	257.00	222.00	102.00	11.00	3772.00	19.33	3.00	12.70	16.60	1				28
Dry Creek (D4)	09-Aug-95	0.00	462.00	1435.00	1009.00	332.00	70.00	154.00	139.00	60.00	14.00	3675.00	11.89	2.01	7.97	20.80	2				28
Dry Creek (D4)	09-Aug-95	0.00	524.00	563.00	819.00	434.00	97.00	149.00	181.00	67.00	12.00	2846.00	17.78	2.78	11.60	16.43	3				28
Dry Creek (D4)	09-Aug-95	0.00	0.00	832.00	925.00	569.00	119.00	224.00	330.00	215.00	22.00	3236.00	28.12	7.32	17.12	9.98	3				28
Dry Creek (D4)	09-Aug-95	0.00	901.00	1149.00	854.00	607.00	185.00	374.00	211.00	27.00	16.00	4324.00	18.80	0.99	13.53	18.54	4				28
Dry Creek (D4)	09-Aug-95	0.00	374.00	962.00	801.00	556.00	190.00	408.00	334.00	52.00	9.00	3686.00	26.94	1.65	20.13	13.53	4				28
Dry Creek (D4)	29-Jun-99	0.00	1413.20	541.70	666.60	345.70	115.00	275.80	324.20	87.40	4.70	3774.30	21.38	2.44	15.90	19.45	1	15N	10W	17	28
Dry Creek (D4)	29-Jun-99	0.00	810.70	860.00	663.30	335.60	94.40	189.70	146.00	51.30	11.80	3162.80	15.59	2.00	10.61	20.81	2	15N	10W	17	28
Dry Creek (D4)	29-Jun-99	0.00	0.00	538.90	1320.20	668.60	177.40	326.70	173.80	89.60	16.80	3312.00	23.68	3.21	15.11	11.32	3	15N	10W	17	28
Dry Creek (D4)	29-Jun-99	0.00	0.00	332.60	968.80	718.30	206.10	359.80	239.30	118.40	22.20	2965.50	31.89	4.74	20.20	8.78	3	15N	10W	17	28
Dry Creek (D4)	29-Jun-99	0.00	0.00	290.20	725.10	385.10	88.50	173.00	154.40	47.60	5.60	1869.50	25.09	2.85	17.51	10.81	4	15N	10W	17	28
Dry Creek (D4)	29-Jun-99	0.00	0.00	464.20	777.60	582.20	206.50	426.60	397.30	200.20	17.90	3072.50	40.63	7.10	26.82	7.44	4	15N	10W	17	28
Dry Creek	29-Jun-00	0.00	1328.90	585.50	735.90	431.80	106.80	290.00	253.70	111.30	5.00	3848.90	19.92	3.02	14.13	19.14	1	15N	10W	17	28
Dry Creek	29-Jun-00	0.00	387.10	945.00	924.20	736.80	235.90	469.80	400.80	156.00	16.50	4282.10	30.10	4.26	20.33	11.45	1	15N	10W	17	28
Dry Creek	29-Jun-00	0.00	753.00	452.90	982.90	553.90	159.10	389.00	396.60	177.10	17.50	3892.00	29.53	5.00	20.18	12.09	2	15N	10W	17	28
Dry Creek	29-Jun-00	0.00	1226.10	953.40	797.90	336.50	78.00	128.20	98.00	54.60	11.30	3684.00	10.05	1.79	6.24	25.52	3	15N	10W	17	28
Dry Creek	29-Jun-00	0.00	340.10	1325.00	698.50	437.10	150.50	277.10	241.40	68.50	15.00	3553.20	21.18	2.35	14.59	16.23	4	15N	10W	17	28
Dry Creek	29-Jun-00	0.00	310.40	998.40	1302.60	599.80	115.50	245.90	260.00	114.70	20.30	3967.60	19.06	3.40	12.75	14.44	5	15N	10W	17	28
Dry Creek	13-Jun-01	0.00	288.80	482.20	750.70	660.40	217.70	405.00	275.40	101.60	59.40	3341.20	32.68	4.97	20.99	9.81	1	15N	10W	17	28
Dry Creek	13-Jun-01	0.00	481.90	959.20	692.30	341.70	100.20	158.00	165.80	50.00	58.10	3017.20	17.97	3.58	11.05	16.93	2	15N	10W	17	28
Dry Creek	13-Jun-01	0.00	1751.00	477.50	725.70	368.60	101.50	175.00	163.80	102.30	25.10	3890.50	14.59	3.27	8.71	23.54	3	15N	10W	17	28
Dry Creek	13-Jun-01	0.00	222.40	1159.00	533.20	400.40	123.50	278.40	300.80	126.50	38.90	3183.10	27.27	5.20	18.20	12.74	4	15N	10W	17	28
Dry Creek	13-Jun-01	0.00	0.00	1472.40	850.60	589.30	211.70	418.50	279.50	108.90	83.70	4014.60	27.46	4.80	17.39	11.67	5	15N	10W	17	28
Dry Creek	13-Jun-01	0.00	529.50	502.60	605.50	335.80	87.20	200.90	238.10	86.40	24.10	2610.10	24.39	4.23	16.82	14.29	6	15N	10W	17	28
Dry Creek	09-Jul-02	0.00	1410.90	1330.00	750.60	369.90	101.00	201.00	94.70	17.00	14.22	4289.32	9.98	0.73	6.89	27.13	1	15N	10W	17	28
Dry Creek	09-Jul-02	0.00	2370.80	652.70	300.10	253.60	76.10	141.70	149.80	130.50	26.90	4102.20	12.80	3.84	7.11	29.37	2	15N	10W	17	28
Dry Creek	09-Jul-02	0.00	1432.30	857.80	955.20	603.50	189.70	411.60	303.80	125.80	35.77	4915.47	21.70	3.29	14.55	17.33	3	15N	10W	17	28

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76.2 mm Sieve (Grams)	50.8 mm Sieve (Grams)	25.4 mm Sieve (Grams)	12.7 mm Sieve (Grams)	6.3 mm Sieve (Grams)	4.76 mm Sieve (Grams)	2.38 mm Sieve (Grams)	0.85 mm Sieve (Grams)	0.074 mm Sieve (Grams)	<0.074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Dry Creek	09-Jul-02	0.00	0.00	698.00	1113.60	650.00	189.30	373.70	355.80	221.90	36.04	3638.34	32.34	7.09	20.05	8.93	3	15N	10W	17	28
Dry Creek	09-Jul-02	0.00	340.40	539.10	679.80	697.50	216.50	458.50	373.80	102.20	21.81	3429.61	34.20	3.62	24.27	10.10	4	15N	10W	17	28
Dry Creek	09-Jul-02	0.00	518.90	870.00	755.40	499.80	140.50	308.60	421.90	326.20	37.47	3878.77	31.83	9.38	18.83	10.54	5	15N	10W	17	28
Blackfoot (Dalton)	12-Nov-02	0.00	0.00	1367.70	1527.80	830.70	210.00	362.40	353.80	1063.90	72.95	5789.25	35.64	19.64	12.37	7.02	1	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	12-Nov-02	0.00	0.00	2401.90	1460.50	596.50	113.00	322.30	246.30	705.30	104.28	5950.08	25.06	13.61	9.56	10.92	2	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	12-Nov-02	0.00	0.00	964.50	1559.30	955.90	273.10	435.50	453.90	1034.70	49.22	5726.12	39.23	18.93	15.53	6.30	3	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	12-Nov-02	0.00	276.10	1490.30	1695.30	803.10	224.70	510.60	607.20	586.00	59.83	6253.13	31.80	10.33	17.88	9.46	4	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	12-Nov-02	0.00	1088.70	518.00	506.80	502.90	116.40	233.00	256.30	480.30	65.09	3767.49	30.55	14.48	12.99	11.09	5	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	12-Nov-02	0.00	1351.40	1864.00	971.30	456.70	88.30	111.20	73.40	530.80	79.18	5526.28	15.98	11.04	3.34	17.90	6	14N	9W	28, 21, 22, 27	32
Alice)	05-Nov-02	0.00	799.50	999.70	670.60	488.50	159.80	429.80	416.10	248.20	40.84	4253.04	30.44	6.80	19.89	12.46	1	14N	SW	13	32
Alice)	05-Nov-02	0.00	294.40	1038.10	827.10	633.20	217.70	523.90	628.90	420.80	57.00	4641.10	39.82	10.29	24.84	8.07	2	14N	SW	13	32
Alice)	05-Nov-02	0.00	0.00	1084.30	590.30	506.40	174.70	425.00	393.30	212.40	48.80	3435.20	36.51	7.60	23.82	8.96	3	14N	SW	13	32
Alice)	05-Nov-02	0.00	0.00	1140.50	1250.50	544.80	151.20	412.00	532.00	211.10	85.42	4337.52	32.09	6.84	21.76	9.33	4	14N	SW	13	32
Alice)	05-Nov-02	0.00	453.80	1894.70	1216.30	401.60	82.40	152.10	54.90	33.90	30.47	4320.17	8.19	1.49	4.79	22.78	5	14N	SW	13	32
Alice)	05-Nov-02	0.00	253.20	1088.80	755.80	639.40	202.40	439.00	529.40	622.00	60.59	4590.59	40.37	14.87	21.10	7.36	6	14N	SW	13	32
Alice)	29-Oct-01	0.00	1183.70	1061.00	811.80	489.60	117.90	280.30	321.10	294.10	75.70	4635.20	23.50	7.98	12.97	14.85	1	14N	SW	13	32
Alice)	29-Oct-01	0.00	299.70	604.30	747.60	617.60	183.90	355.80	487.50	306.20	55.10	3657.70	37.96	9.88	23.05	8.03	2	14N	SW	13	32
Alice)	29-Oct-01	0.00	0.00	1109.90	1043.10	448.70	132.20	236.00	156.90	99.60	66.30	3292.70	20.99	5.04	11.93	12.94	3	14N	SW	13	32
Alice)	29-Oct-01	0.00	0.00	777.60	1030.40	730.70	194.40	449.20	390.90	289.20	83.30	3945.70	35.66	9.44	21.29	7.80	4	14N	SW	13	32
Alice)	29-Oct-01	0.00	0.00	1481.10	593.70	510.10	176.70	387.90	403.90	292.50	87.50	3933.40	34.28	9.56	20.13	9.29	5	14N	SW	13	32
Alice)	29-Oct-01	0.00	845.90	792.00	433.20	464.10	138.00	284.10	358.50	334.40	41.30	3691.50	31.32	10.18	17.41	11.74	6	14N	SW	13	32
Blackfoot (Dalton)	08-Nov-01	0.00	793.50	1131.40	1139.30	662.50	175.40	307.60	292.20	745.80	17.60	5265.30	29.22	14.50	11.39	10.66	1	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	08-Nov-01	0.00	0.00	804.60	1576.90	1269.40	381.40	767.20	758.00	943.00	8.00	6508.50	43.91	14.61	23.43	6.01	2	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	08-Nov-01	0.00	0.00	1205.80	1420.50	807.70	208.80	451.30	453.10	572.40	25.70	5145.30	33.26	11.62	17.58	8.51	3	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	08-Nov-01	0.00	0.00	1618.70	1393.80	683.10	194.40	357.60	340.80	481.10	77.40	5146.90	28.20	10.85	13.57	10.02	4	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	08-Nov-01	0.00	827.50	1606.30	1119.30	827.60	241.60	509.20	517.50	685.90	54.40	6389.30	31.44	11.59	16.07	10.54	5	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	08-Nov-01	0.00	474.30	971.40	1247.70	716.40	184.80	375.70	391.00	715.30	35.00	5111.60	33.29	14.68	15.00	8.79	6	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	14-Nov-00	0.00	926.30	1240.40	1159.90	658.90	206.40	456.10	650.50	670.70	68.40	5047.70	34.10	12.22	18.46	9.75	1	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	14-Nov-00	0.00	708.00	1084.30	1535.40	1183.60	319.10	568.30	498.00	829.70	95.10	6821.50	33.87	13.56	15.63	8.54	2	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	14-Nov-00	0.00	287.80	2457.70	1643.40	642.30	161.30	219.70	41.10	117.70	34.90	5605.90	10.25	2.72	4.65	20.02	3	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	14-Nov-00	0.00	0.00	1756.60	1768.20	649.00	64.20	94.80	65.00	407.00	210.30	5015.10	16.78	12.31	3.19	11.67	4	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	14-Nov-00	0.00	1493.60	1691.60	865.10	324.20	76.90	126.00	140.10	594.40	67.50	5379.40	18.68	12.30	4.95	17.24	5	14N	9W	28, 21, 22, 27	32
Blackfoot (Dalton)	14-Nov-00	0.00	1318.10	1828.50	961.30	694.30	227.60	408.80	249.70	395.10	68.10	6151.50	21.93	7.53	10.70	15.92	6	14N	9W	28, 21, 22,27	32
Blackfoot (Landers-Alice)	26-Oct-00	0.00	1486.30	263.10	634.90	546.70	168.40	354.10	261.10	149.50	12.30	3876.40	24.39	4.17	15.87	16.80	1	14N	SW	13	32
Blackfoot (Landers-Alice)	26-Oct-00	0.00	1017.00	627.70	822.20	594.40	186.20	408.50	492.40	252.70	28.40	4429.60	30.89	6.35	20.34	12.13	2	14N	SW	13	32
Blackfoot (Landers-Alice)	26-Oct-00	0.00	572.80	1087.90	820.80	543.80	155.10	283.20	281.70	135.00	33.50	3913.80	22.70	4.31	14.43	14.73	3	14N	SW	13	32
Blackfoot (Landers-Alice)	26-Oct-00	0.00	0.00	1613.00	1481.00	703.40	170.00	276.10	204.10	107.20	36.80	4591.60	17.30	3.14	10.46	14.75	4	14N	SW	13	32
Blackfoot (Landers-Alice)	26-Oct-00	0.00	248.70	887.30	1381.50	795.10	183.50	238.80	100.40	60.00	41.70	3937.00	15.86	2.58	8.62	14.79	5	14N	SW	13	32
Blackfoot (Landers-Alice)	26-Oct-00	0.00	1397.70	1228.20	635.40	486.90	154.00	325.30	320.00	388.20	80.00	5015.70	25.27	9.33	12.87	14.78	6	14N	SW	13	32
Blackfoot-NevOg	06-Nov-95	0.00	0.00	1014.00	1181.00	978.00	281.00	644.00	734.00	623.00	59.00	5514.00	42.46	12.37	24.99	6.54	1				32
Blackfoot-NevOg	06-Nov-95	0.00	0.00	570.00	1233.00	958.00	300.00	613.00	669.00	552.00	61.00	4956.00	44.29	12.37	25.87	5.97	1				32
Blackfoot-NevOg	06-Nov-95	0.00	0.00	766.00	1214.00	549.00	187.00	404.00	482.00	513.00	52.00	4167.00	39.31	13.56	21.26	6.99	1				32
Blackfoot-NevOg	06-Nov-95	0.00	0.00	1597.00	1322.00	570.00	178.00	356.00	476.00	483.00	41.00	5023.00	30.54	10.43	16.55	9.81	2				32
Blackfoot-NevOg	06-Nov-95	0.00	465.00	1124.00	893.00	539.00	153.00	272.00	382.00	953.00	70.00	4861.00	37.85	21.05	13.45	7.37	3				32
Blackfoot-NevOg	06-Nov-95	0.00	0.00	1624.00	1225.00	793.00	217.00	456.00	310.00	423.00	22.00	5070.00	28.17	8.78	15.11	10.68	4				32
Blackfoot (Dalton)	03-Nov-95	0.00	2502.00	770.00	908.00	707.00	207.00	428.00	453.00	428.00	33.00	6436.00	24.07	7.16	13.69	16.74	1				32
Blackfoot (Dalton)	03-Nov-95	0.00	1414.00	1258.00	828.00	701.00	191.00	422.00	445.00	496.00	25.00	5780.00	27.32	9.01	15.00	13.59	1				32
Blackfoot (Dalton)	03-Nov-95	0.00	748.00	1105.00	1315.00	869.00	238.00	430.00	408.00	421.00	25.00	5559.00	27.38	8.02	15.07	11.76	2				32
Blackfoot (Dalton)	03-Nov-95	0.00	0.00	1366.00	1522.00	925.00	170.00	245.00	29.00	633.00	107.00	4897.00	22.14	15.11	3.55	9.82	2				32
Blackfoot (Dalton)	03-Nov-95	0.00	525.00	976.00	1367.00	960.00	215.00	425.00	319.00	750.00	28.00	5565.00	31.21	13.98	13.37	9.14	3				32
Blackfoot (Dalton)	03-Nov-95	0.00	0.00	860.00	1055.00	887.00	237.00	410.00	429.00	558.00	49.00	4485.00	37.53	13.53	18.71	7.08	4				32
Blackfoot (Helmville)	13-Nov-95	0.00	0.00	1767.00	924.00	626.00	193.00	452.00	437.00	486.00	51.00	4936.00	32.80	10.88	18.01	9.55	1				32
Blackfoot (Helmville)	13-Nov-95	0.00	0.00	1200.00	562.00	372.00	138.00	333.00	430.00	402.00	48.00	3485.00	38.77	12.91	21.88	8.03	1				32
Blackfoot (Helmville)	13-Nov-95	1292.00	887.00	852.00	757.00	466.00	176.00	416.00	414.00	449.00	66.00	5775.00	26.34	8.92	14.37	16.90	2				32
Blackfoot (Helmville)	13-Nov-95	0.00	195.00	625.00	1545.00	573.00	106.00	185.00	155.00	438.00	21.00	3843.00	23.55	11.94	8.85	10.43	2				32
Blackfoot (Helmville)	13-Nov-95	0.00	288.00	1392.00	1123.00	709.00	222.00	526.00	536.00	459.00	78.00	5343.00	34.27	10.24	19.88	9.20	3				32

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Blackfoot (Helmville)	13-Nov-95	0.00	0.00	1709.00	951.00	561.00	171.00	394.00	375.00	399.00	39.00	4599.00	29.96	9.52	16.72	10.52	4				32
Blackfoot (Dalton)	09-Nov-94	0.00	497.00	1795.00	1282.00	772.00	235.00	505.00	420.00	774.00	138.00	6418.00	32.28	14.21	14.41	9.29	1	14N	9W	21, 28	32
Blackfoot (Dalton)	09-Nov-94	957.00	0.00	1197.00	705.00	672.00	207.00	487.00	467.00	592.00	41.00	5325.00	33.69	11.89	17.92	11.17	1	14N	9W	21, 28	32
Blackfoot (Dalton)	09-Nov-94	0.00	0.00	1780.00	1056.00	858.00	255.00	541.00	549.00	786.00	62.00	5897.00	37.19	14.38	18.48	7.82	1	14N	9W	21, 28	32
Blackfoot (Dalton)	09-Nov-94	0.00	0.00	689.00	1972.00	1081.00	111.00	76.00	13.00	939.00	170.00	5051.00	25.92	21.96	1.76	6.91	2	14N	9W	21, 28	32
Blackfoot (Dalton)	09-Nov-94	0.00	836.00	1029.00	1180.00	812.00	238.00	375.00	285.00	465.00	98.00	5318.00	27.47	10.59	12.41	11.23	3	14N	9W	21, 28	32
Blackfoot (Dalton)	09-Nov-94	0.00	1077.00	915.00	755.00	731.00	234.00	397.00	479.00	672.00	82.00	5342.00	34.89	14.11	16.40	9.49	4	14N	9W	21, 28	32
Blackfoot (Helmville)	15-Nov-94	0.00	0.00	364.00	2083.00	880.00	147.00	184.00	90.00	809.00	51.00	4608.00	27.80	18.66	5.95	7.33	1	14N	11W	26	32
Blackfoot (Helmville)	15-Nov-94	0.00	0.00	1916.00	880.00	647.00	202.00	416.00	374.00	488.00	41.00	4964.00	30.64	10.66	15.91	10.28	1	14N	11W	26	32
Blackfoot (Helmville)	15-Nov-94	0.00	1395.00	1430.00	791.00	664.00	212.00	326.00	233.00	123.00	19.00	5193.00	17.58	2.73	10.76	19.99	1	14N	11W	26	32
Blackfoot (Helmville)	15-Nov-94	0.00	0.00	972.00	1197.00	723.00	243.00	500.00	637.00	1148.00	40.00	5461.00	47.04	21.77	20.82	5.23	2	14N	11W	26	32
Blackfoot (Helmville)	15-Nov-94	0.00	0.00	622.00	1743.00	832.00	226.00	446.00	508.00	1294.00	32.00	5703.00	43.94	23.25	16.73	5.17	3	14N	11W	26	32
Blackfoot (Helmville)	15-Nov-94	0.00	0.00	1447.00	1250.00	639.00	200.00	398.00	308.00	544.00	68.00	4854.00	31.27	12.61	14.54	9.14	4	14N	11W	26	32
Blackfoot (Nev Ogd)	09-Nov-94	0.00	521.00	443.00	1448.00	1282.00	281.00	422.00	323.00	639.00	85.00	5444.00	32.15	13.30	13.68	8.01	1	14N	10W	34	32
Blackfoot (Nev Ogd)	09-Nov-94	0.00	0.00	1143.00	1379.00	1071.00	274.00	471.00	494.00	1159.00	91.00	6082.00	40.92	20.55	15.87	5.85	1	14N	10W	34	32
Blackfoot (Nev Ogd)	09-Nov-94	0.00	0.00	1765.00	1564.00	952.00	183.00	214.00	121.00	657.00	182.00	5638.00	24.07	14.88	5.94	9.54	1	14N	10W	34	32
Blackfoot (Nev Ogd)	09-Nov-94	0.00	859.00	920.00	978.00	692.00	245.00	517.00	573.00	565.00	63.00	5412.00	36.27	11.60	20.14	9.29	2	14N	10W	34	32
Blackfoot (Nev Ogd)	09-Nov-94	0.00	0.00	838.00	1274.00	913.00	261.00	413.00	267.00	1162.00	37.00	5165.00	41.43	23.21	13.17	5.65	3	14N	10W	34	32
Blackfoot (Nev Ogd)	09-Nov-94	0.00	0.00	1268.00	1774.00	1177.00	280.00	377.00	152.00	541.00	163.00	5732.00	26.40	12.28	9.23	8.96	4	14N	10W	34	32
Blackfoot river (Jct)	10-Nov-93	0.00	989.00	1394.00	905.00	773.00	241.00	493.00	652.00	637.00	74.00	6158.00	34.05	11.55	18.59	10.04	1	10N	11W	NE 26	32
Blackfoot river (Jct)	10-Nov-93	0.00	0.00	1642.00	1532.00	838.00	300.00	573.00	680.00	801.00	83.00	6449.00	37.79	13.71	19.43	7.57	1	10N	11W	NE 26	32
Blackfoot river (Jct)	10-Nov-93	0.00	209.00	1509.00	1356.00	819.00	268.00	532.00	597.00	829.00	77.00	6196.00	37.17	14.62	18.22	7.80	1	10N	11W	NE 26	32
Blackfoot river (Jct)	10-Nov-93	0.00	0.00	1409.00	1556.00	1287.00	314.00	502.00	358.00	569.00	16.00	6011.00	29.26	9.73	14.31	9.40	2	10N	11W	NE 26	32
Blackfoot river (Jct)	10-Nov-93	0.00	589.00	1282.00	1044.00	751.00	278.00	569.00	702.00	786.00	58.00	6059.00	39.49	13.93	20.98	8.03	3	10N	11W	NE 26	32
Blackfoot river (Jct)	10-Nov-93	0.00	1102.00	1079.00	1259.00	1015.00	275.00	460.00	449.00	729.00	69.00	6437.00	30.79	12.40	14.12	10.25	4	10N	11W	NE 26	32
Blackfoot River (Dalton)	08-Nov-93	0.00	380.00	998.00	888.00	866.00	203.00	306.00	357.00	455.00	63.00	4526.00	30.80	11.44	14.87	9.38	1	14N	9W	NE 28	32
Blackfoot River (Dalton)	08-Nov-93	0.00	1708.00	900.00	646.00	545.00	173.00	354.00	463.00	640.00	24.00	5453.00	30.33	12.18	14.98	12.78	1	14N	9W	NE 28	32
Blackfoot River (Dalton)	08-Nov-93	0.00	925.00	1198.00	1044.00	799.00	203.00	292.00	391.00	620.00	42.00	5514.00	28.07	12.01	12.39	11.29	2	14N	9W	NE 28	32
Blackfoot River (Dalton)	08-Nov-93	0.00	0.00	1467.00	1468.00	445.00	55.00	45.00	4.00	261.00	72.00	3817.00	11.45	8.72	1.28	15.18	2	14N	9W	NW 27	32
Blackfoot River (Dalton)	08-Nov-93	0.00	710.00	1304.00	671.00	694.00	196.00	297.00	198.00	512.00	37.00	4619.00	26.85	11.89	10.72	12.12	3	14N	9W	NW 27	32
Blackfoot River (Dalton)	08-Nov-93	0.00	837.00	1063.00	994.00	553.00	182.00	353.00	442.00	533.00	36.00	4893.00	30.96	11.40	15.92	10.98	4	14N	9W	NE 27	32
Blackfoot R. (Nev- Ogd)	09-Nov-93	0.00	0.00	973.00	1377.00	1177.00	391.00	593.00	430.00	517.00	144.00	5602.00	37.04	11.80	18.26	7.13	1	14N	10W	NW 34	32
Blackfoot R. (Nev- Ogd)	09-Nov-93	0.00	344.00	652.00	2290.00	1582.00	140.00	115.00	158.00	787.00	91.00	6159.00	20.96	14.26	4.43	9.20	1	14N	10W	NW 34	32
Blackfoot R. (Nev- Ogd)	09-Nov-93	0.00	0.00	1557.00	1778.00	931.00	200.00	283.00	288.00	626.00	136.00	5799.00	26.44	13.14	9.85	9.27	1	14N	10W	NW 34	32
Blackfoot R. (Nev- Ogd)	09-Nov-93	0.00	562.00	1284.00	773.00	729.00	266.00	465.00	412.00	1068.00	36.00	5615.00	40.02	19.66	15.62	7.55	2	14N	10W	NE 34	32
Blackfoot R. (Nev- Ogd)	09-Nov-93	0.00	98.00	1350.00	1210.00	957.00	236.00	455.00	495.00	817.00	46.00	5664.00	36.18	15.24	16.77	7.59	3	14N	10W	NE 34	32
Blackfoot R. (Nev- Ogd)	09-Nov-93	0.00	0.00	1199.00	2388.00	909.00	111.00	49.00	12.00	950.00	111.00	5739.00	21.66	18.66	1.06	8.98	4	14N	10W	NE 34	32
Blackfoot R. (Moose Cr.)	05-Nov-92	0.00	314.00	703.00	1409.00	1099.00	224.00	289.00	168.00	213.00	104.00	4523.00	22.07	7.01	10.10	10.92	1	14N	10W	NW 34	32
Blackfoot R. (Moose Cr.)	05-Nov-92	0.00	0.00	773.00	932.00	1017.00	270.00	456.00	358.00	423.00	115.00	4344.00	37.34	12.38	18.74	6.85	1	14N	10W	NW 34	32
Blackfoot R. (Moose Cr.)	05-Nov-92	0.00	475.00	1048.00	1072.00	747.00	151.00	303.00	237.00	511.00	51.00	4595.00	27.27	12.23	11.75	10.54	1	14N	10W	NW 34	32
Blackfoot R. (Moose Cr.)	05-Nov-92	0.00	0.00	1570.00	796.00	596.00	189.00	369.00	434.00	516.00	29.00	4499.00	34.16	12.11	17.85	9.05	2	14N	10W	NE 34	32
Blackfoot R. (Moose Cr.)	05-Nov-92	0.00	0.00	1008.00	1022.00	579.00	176.00	357.00	319.00	445.00	22.00	3928.00	33.58	11.89	17.21	8.66	3	14N	10W	NE 34	32
Blackfoot R. (Moose Cr.)	05-Nov-92	0.00	0.00	1110.00	1385.00	972.00	187.00	208.00	112.00	606.00	26.00	4606.00	24.73	13.72	6.95	9.55	4	14N	10W	NE 34	32
Blackfoot R. (Jct. 272)	12-Nov-92	0.00	295.00	1085.00	995.00	839.00	317.00	737.00	810.00	534.00	83.00	5695.00	43.56	10.83	27.16	7.12	1	14N	11W	NE 26	32
Blackfoot R. (Jct. 272)	12-Nov-92	0.00	0.00	449.00	2212.00	1311.00	177.00	159.00	194.00	1104.00	34.00	5640.00	29.57	20.18	6.26	6.71	1	14N	11W	NE 26	32
Blackfoot R. (Jct. 272)	12-Nov-92	0.00	0.00	984.00	1518.00	1087.00	294.00	508.00	269.00	970.00	54.00	5784.00	37.95	17.70	15.16	6.59	1	14N	11W	NE 26	32
Blackfoot R. (Jct. 272)	12-Nov-92	0.00	0.00	1010.00	1191.00	1169.00	428.00	899.00	745.00	897.00	50.00	6389.00	47.25	14.82	25.73	5.77	2	14N	11W	NE 26	32
Blackfoot R. (Jct. 272)	12-Nov-92	0.00	0.00	1419.00	1365.00	735.00	256.00	578.00	653.00	605.00	67.00	5678.00	38.02	11.84	21.68	7.77	4	14N	11W	NE 26	32
Blackfoot R. (Dalton)	05-Nov-92	0.00	1178.00	926.00	753.00	342.00	81.00	156.00	215.00	412.00	56.00	4119.00	22.34	11.36	9.01	15.12	1	14N	9W	NE 28	32
Blackfoot R. (Dalton)	05-Nov-92	0.00	334.00	1976.00	883.00	449.00	84.00	148.00	185.00	476.00	67.00	4602.00	20.86	11.80	7.24	13.64	1	14N	9W	NE 28	32
Blackfoot R. (Dalton)	05-Nov-92	0.00	1149.00	1144.00	1002.00	603.00	186.00	327.00	407.00	665.00	41.00	5524.00	29.44	12.78	13.29	11.57	1	14N	9W	NE 28	32
Blackfoot R. (Dalton)	05-Nov-92	0.00	238.00	1397.00	1156.00	662.00	207.00	422.00	327.00	296.00	39.00	4744.00	27.21	7.06	15.79	11.68	2	14N	9W	NW 27	32
Blackfoot R. (Dalton)	05-Nov-92	0.00	0.00	1842.00	1007.00	692.00	191.00	387.00	377.00	371.00	34.00	4901.00	27.75	8.26	15.59	11.18	3	14N	9W	NW 27	32
Blackfoot R. (Dalton)	05-Nov-92	0.00	0.00	1441.00	1162.00	670.00	167.00	288.00	285.00	339.00	135.00	4537.00	27.86	11.55	12.63	9.52	4	14N	9W	NE 27	32
Blackfoot (Aspen Grove)	03-Nov-92	509.00	341.00	918.00	350.00	392.00	122.00	280.00	253.00	108.00	19.00	3292.00	23.75	3.86	16.19	17.90	1	15N	7W	NW 35	32
Blackfoot (Aspen Grove)	03-Nov-92	0.00	402.00	1157.00	603.00	425.00	153.00	305.00	290.00	128.00	27.00	3490.00	25.87	4.44	17.05	14.02	1	15N	7W	NW 35	32

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Blackfoot (Aspen Grove)	03-Nov-92	0.00	276.00	956.00	816.00	539.00	139.00	252.00	269.00	138.00	40.00	3425.00	24.47	5.20	15.21	12.66	2	14N	7W	NW 8	32
Blackfoot (Aspen Grove)	03-Nov-92	0.00	422.00	914.00	632.00	572.00	188.00	300.00	286.00	249.00	36.00	3599.00	29.42	7.92	15.28	11.40	2	14N	7W	NW 8	32
Blackfoot (Aspen Grove)	03-Nov-92	997.00	316.00	753.00	683.00	334.00	65.00	111.00	53.00	105.00	22.00	3439.00	10.35	3.59	4.77	27.65	3	14N	7W	NE 13	32
Blackfoot (Aspen Grove)	03-Nov-92	0.00	0.00	1370.00	502.00	443.00	128.00	284.00	353.00	118.00	34.00	3242.00	28.59	4.69	19.96	11.85	4	14N	7W	NE 13	32
No. Fk. Blackfoot R.	15-Oct-92	0.00	0.00	1372.00	1575.00	695.00	150.00	252.00	256.00	478.00	53.00	4831.00	24.61	10.99	10.52	10.50	1	16N	11W	NW 23	25
No. Fk. Blackfoot R.	15-Oct-92	0.00	0.00	995.00	1244.00	722.00	177.00	315.00	424.00	895.00	47.00	4719.00	39.37	19.96	15.66	6.29	1	16N	11W	NW 23	25
No. Fk. Blackfoot R.	15-Oct-92	0.00	878.00	1304.00	784.00	730.00	204.00	460.00	572.00	309.00	37.00	5278.00	29.97	6.56	19.55	12.18	2	16N	11W	NW 23	25
No. Fk. Blackfoot R.	15-Oct-92	0.00	1010.00	1702.00	1324.00	753.00	234.00	453.00	521.00	370.00	62.00	6429.00	25.51	6.72	15.15	13.48	2	16N	11W	NW 23	25
No. Fk. Blackfoot R.	15-Oct-92	0.00	489.00	1411.00	582.00	568.00	190.00	400.00	509.00	260.00	36.00	4445.00	31.38	6.66	20.45	11.67	2	16N	11W	NW 23	25
No. Fk. Blackfoot R.	15-Oct-92	0.00	0.00	1017.00	1242.00	431.00	93.00	344.00	665.00	327.00	69.00	4188.00	35.77	9.46	24.09	8.12	3	16N	11W	SE 14	25
No. Fk. Blackfoot R.	15-Oct-92	0.00	347.00	1996.00	766.00	425.00	106.00	169.00	194.00	72.00	17.00	4092.00	13.64	2.17	8.87	20.20	4	16N	11W	SE 14	25
No. Fk. Blackfoot R.	15-Oct-92	0.00	869.00	885.00	1163.00	758.00	153.00	337.00	376.00	147.00	36.00	4734.00	22.37	3.87	15.05	14.38	5	16N	11W	SE 14	25
No. Fk. Blackfoot R.	15-Oct-92	0.00	383.00	1482.00	1750.00	258.00	16.00	43.00	53.00	164.00	81.00	4230.00	8.44	5.79	2.27	18.92	5	16N	11W	SE 14	25
Blackfoot R. (Jct. 272)	20-Nov-91	0.00	859.00	1742.00	1089.00	1012.00	343.00	796.00	950.00	680.00	82.00	7553.00	37.75	10.09	23.12	9.07	1	14N	11W	26A	32
Blackfoot R. (Jct. 272)	20-Nov-91	0.00	270.00	1864.00	1387.00	974.00	309.00	682.00	550.00	617.00	72.00	6725.00	33.16	10.25	18.32	9.49	1	14N	11W	26A	32
Blackfoot R. (Jct. 272)	20-Nov-91	0.00	0.00	1612.00	1547.00	1055.00	323.00	640.00	626.00	737.00	60.00	6600.00	36.15	12.08	19.18	7.98	1	14N	11W	26A	32
Blackfoot R. (Jct. 272)	20-Nov-91	0.00	0.00	1263.00	2001.00	1487.00	367.00	687.00	480.00	1094.00	78.00	7457.00	36.29	15.72	15.65	6.97	2	14N	11W	26A	32
Blackfoot R. (Jct. 272)	20-Nov-91	0.00	0.00	711.00	1776.00	1421.00	295.00	595.00	431.00	990.00	79.00	5298.00	37.95	16.97	16.29	6.18	3	14N	11W	26A	32
Blackfoot R. (Jct. 272)	20-Nov-91	0.00	646.00	1968.00	1386.00	707.00	214.00	499.00	582.00	545.00	152.00	6699.00	29.74	10.40	16.14	10.71	4	14N	11W	26A	32
Blackfoot (Moose Crk)	19-Nov-91	0.00	0.00	649.00	1493.00	1398.00	395.00	702.00	364.00	583.00	36.00	5620.00	37.01	11.01	18.97	7.19	1	14N	10W	34B	32
Blackfoot (Moose Crk)	19-Nov-91	0.00	0.00	625.00	1291.00	1455.00	415.00	829.00	479.00	696.00	42.00	5832.00	42.20	12.65	22.43	6.24	1	14N	10W	34B	32
Blackfoot (Moose Crk)	19-Nov-91	0.00	0.00	982.00	1308.00	1285.00	369.00	708.00	390.00	504.00	44.00	5590.00	36.05	9.80	19.64	7.84	1	14N	10W	34B	32
Blackfoot (Moose Crk)	19-Nov-91	0.00	0.00	1196.00	1300.00	1161.00	330.00	627.00	628.00	925.00	37.00	6204.00	41.05	15.51	20.23	6.52	2	14N	10W	34A	32
Blackfoot (Moose Crk)	19-Nov-91	0.00	0.00	737.00	1257.00	1103.00	387.00	791.00	1268.00	1760.00	30.00	7333.00	57.77	24.41	28.08	3.75	3	14N	10W	34A	32
Blackfoot (Moose Crk)	19-Nov-91	0.00	0.00	845.00	3111.00	1646.00	214.00	148.00	10.00	353.00	208.00	6535.00	14.28	8.58	2.42	10.80	4	14N	10W	34A	32
Blackfoot R. (Dalton)	19-Nov-91	0.00	889.00	1572.00	934.00	552.00	133.00	213.00	192.00	409.00	53.00	4947.00	20.21	9.34	8.19	15.34	1	14N	9W	28A	32
Blackfoot R. (Dalton)	19-Nov-91	1112.00	576.00	1194.00	1035.00	768.00	231.00	424.00	485.00	674.00	57.00	6556.00	28.54	11.15	13.87	13.30	1	14N	9W	28A	32
Blackfoot R. (Dalton)	19-Nov-91	0.00	1145.00	1624.00	1065.00	739.00	190.00	393.00	485.00	777.00	60.00	6478.00	29.41	12.92	13.55	11.34	1	14N	9W	28A	32
Blackfoot R. (Dalton)	19-Nov-91	0.00	925.00	2357.00	1538.00	935.00	204.00	358.00	165.00	958.00	60.00	7500.00	23.27	13.57	6.97	12.60	2	14N	9W	27B	32
Blackfoot R. (Dalton)	19-Nov-91	0.00	0.00	1406.00	2058.00	1291.00	357.00	725.00	525.00	931.00	21.00	7334.00	35.03	12.98	17.04	7.87	3	14N	9W	27B	32
Blackfoot R. (Dalton)	19-Nov-91	0.00	1668.00	810.00	1048.00	1005.00	297.00	577.00	799.00	943.00	73.00	7220.00	37.24	14.07	19.06	9.02	4	14N	9W	27A	32
Blackfoot R. (Dalton)	05-Nov-90	0.00	1517.00	1139.00	915.00	786.00	260.00	502.00	783.00	913.00	33.00	5848.00	36.38	13.81	18.76	9.70	1				32
Blackfoot R. (Dalton)	05-Nov-90	0.00	795.00	1228.00	967.00	757.00	209.00	357.00	497.00	561.00	37.00	5418.00	30.84	11.04	15.95	10.68	1				32
Blackfoot R. (Dalton)	05-Nov-90	0.00	0.00	1593.00	946.00	1058.00	376.00	717.00	952.00	1177.00	73.00	6912.00	47.82	18.08	24.29	5.56	1				32
Blackfoot R. (Dalton)	05-Nov-90	0.00	598.00	1302.00	1161.00	774.00	250.00	377.00	607.00	1037.00	25.00	6131.00	37.45	17.32	16.05	7.94	2				32
Blackfoot R. (Dalton)	05-Nov-90	0.00	175.00	1319.00	1636.00	1024.00	274.00	435.00	624.00	1235.00	15.00	6737.00	38.34	18.55	15.72	6.86	3				32
Blackfoot R. (Dalton)	05-Nov-90	0.00	1131.00	1024.00	716.00	717.00	288.00	518.00	528.00	520.00	37.00	5479.00	34.51	10.17	19.09	10.78	4				32
Blackfoot R. (Moose Crk.)	06-Nov-90	0.00	419.00	793.00	818.00	849.00	265.00	464.00	481.00	672.00	34.00	4795.00	39.96	14.72	19.71	7.39	1				32
Blackfoot R. (Jct.)	07-Nov-90	0.00	791.00	1148.00	1121.00	746.00	242.00	547.00	696.00	658.00	77.00	5036.00	36.94	12.34	20.59	8.79	1				32
Blackfoot R. (Jct.)	07-Nov-90	0.00	614.00	1453.00	1409.00	1040.00	350.00	866.00	1070.00	1039.00	70.00	7921.00	42.99	14.00	24.44	7.11	1				32
Blackfoot R. (Jct.)	07-Nov-90	0.00	0.00	1251.00	1484.00	1233.00	386.00	797.00	881.00	1191.00	43.00	7266.00	45.39	16.98	23.09	5.77	1				32
Blackfoot R. (Jct.)	07-Nov-90	0.00	0.00	162.00	1401.00	2231.00	614.00	923.00	455.00	1010.00	116.00	6822.00	45.85	16.51	20.35	4.87	2				32
Blackfoot R. (Jct.)	07-Nov-90	0.00	0.00	2385.00	1701.00	751.00	159.00	236.00	275.00	906.00	59.00	5482.00	25.38	14.89	7.88	10.45	3				32
Blackfoot R. (Jct.)	07-Nov-90	0.00	0.00	891.00	1673.00	1089.00	346.00	699.00	893.00	830.00	71.00	5492.00	43.73	13.88	24.52	6.03	4				32
Blackfoot R. (Moose Crk.)	06-Nov-90	0.00	450.00	874.00	792.00	755.00	252.00	386.00	468.00	659.00	21.00	4667.00	38.48	14.78	18.30	7.90	1				32
Blackfoot R. (Moose Crk.)	06-Nov-90	0.00	517.00	1704.00	847.00	943.00	318.00	529.00	537.00	977.00	21.00	6393.00	37.26	15.61	16.67	8.42	1				32
Blackfoot R. (Moose Crk.)	06-Nov-90	0.00	366.00	1261.00	1057.00	994.00	308.00	625.00	859.00	790.00	74.00	5334.00	41.93	13.64	23.43	7.02	2				32
Blackfoot R. (Moose Crk.)	06-Nov-90	0.00	341.00	1748.00	1665.00	991.00	324.00	558.00	822.00	1145.00	35.00	7629.00	37.80	15.47	18.09	7.71	3				32
Blackfoot R. (Moose Crk.)	06-Nov-90	0.00	281.00	1589.00	1533.00	351.00	92.00	154.00	115.00	565.00	30.00	4710.00	20.30	12.63	5.71	13.14	4				32
Blackfoot R. (Dalton Bdg)	05-Nov-89	0.00	206.00	1703.00	1359.00	941.00	362.00	659.00	930.00	1108.00	37.00	7325.00	42.40	15.63	21.83	6.90	1				32
Blackfoot R. (Dalton Bdg)	05-Nov-89	0.00	0.00	1184.00	1087.00	968.00	346.00	635.00	786.00	1428.00	25.00	6459.00	49.85	22.50	22.00	4.92	1				32
Blackfoot R. (Dalton Bdg)	05-Nov-89	0.00	868.00	999.00	1245.00	1124.00	365.00	687.00	785.00	1230.00	12.00	7315.00	42.09	16.98	20.12	7.09	1				32
Blackfoot R. (Dalton Bdg)	05-Nov-89	0.00	1607.00	1180.00	1030.00	851.00	318.00	715.00	550.00	571.00	73.00	6895.00	32.30	9.34	18.35	12.69	2				32
Blackfoot R. (Dalton Bdg)	05-Nov-89	739.00	1795.00	1222.00	821.00	775.00	254.00	503.00	424.00	395.00	14.00	6942.00	22.90	5.89	13.35	18.64	3				32
Blackfoot R. (Dalton Bdg)	05-Nov-89	934.00	439.00	717.00	1498.00	1386.00	334.00	528.00	682.00	1116.00	28.00	7663.00	35.08	14.93	15.80	8.93	3				32
Blackfoot R. (Dalton Bdg)	05-Nov-89	0.00	197.00	1080.00	1037.00	926.00	284.00	559.00	710.00	893.00	14.00	5700.00	43.16	15.91	22.26	6.53	3				32

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Blackfoot R. (Dalton Bdg)	05-Nov-89	0.00	434.00	2017.00	1851.00	1165.00	290.00	566.00	701.00	941.00	37.00	8002.00	31.68	12.22	15.83	9.40	4				32
Blackfoot R. (Dalton Bdg)	05-Nov-89	0.00	188.00	1795.00	1542.00	1016.00	284.00	463.00	359.00	576.00	16.00	6239.00	27.22	9.49	13.18	10.89	5				32
Blackfoot R. (Dalton Bdg)	05-Nov-89	0.00	538.00	1682.00	1327.00	916.00	281.00	721.00	715.00	652.00	93.00	6935.00	35.65	10.89	20.71	9.02	6				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	223.00	1158.00	2281.00	1074.00	271.00	633.00	748.00	962.00	100.00	7450.00	36.43	14.26	18.54	7.33	1				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	329.00	940.00	1685.00	859.00	211.00	298.00	246.00	703.00	71.00	5342.00	28.62	14.49	10.18	9.05	1				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	0.00	882.00	1755.00	1448.00	341.00	688.00	727.00	780.00	49.00	6670.00	38.76	12.43	21.21	6.70	1				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	0.00	1240.00	2059.00	1200.00	282.00	464.00	480.00	627.00	101.00	6453.00	30.28	11.28	14.63	8.45	2				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	142.00	1290.00	2284.00	724.00	102.00	168.00	97.00	986.00	41.00	5834.00	23.89	17.60	4.54	9.58	2				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	0.00	213.00	1532.00	1528.00	431.00	822.00	574.00	898.00	21.00	6019.00	45.62	15.27	23.19	5.29	2				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	0.00	935.00	2301.00	1350.00	324.00	483.00	252.00	1266.00	63.00	6974.00	34.24	19.06	10.54	6.76	3				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	383.00	2122.00	1501.00	895.00	245.00	524.00	505.00	433.00	82.00	6690.00	26.74	7.70	15.38	11.74	4				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	0.00	756.00	1978.00	1224.00	360.00	787.00	923.00	1234.00	58.00	7320.00	45.93	17.65	23.35	5.33	4				32
Blackfoot R. (Jct. 272)	07-Nov-89	0.00	0.00	1503.00	1352.00	595.00	219.00	645.00	1046.00	481.00	51.00	5902.00	41.38	9.01	28.65	7.62	4				32
Campground)	09-Nov-89	0.00	0.00	39.00	1337.00	1770.00	548.00	815.00	528.00	1087.00	342.00	6466.00	51.35	22.10	20.77	3.63	1				32
Campground)	09-Nov-89	0.00	0.00	1331.00	1405.00	1298.00	373.00	657.00	569.00	1126.00	26.00	6795.00	40.63	16.95	18.19	6.50	1				32
Campground)	09-Nov-89	0.00	234.00	1388.00	1363.00	1191.00	395.00	704.00	656.00	1081.00	66.00	7088.00	41.08	16.18	19.33	6.78	1				32
Campground)	09-Nov-89	0.00	430.00	744.00	1286.00	1562.00	457.00	769.00	651.00	904.00	245.00	7058.00	43.02	16.28	20.26	5.77	2				32
Campground)	09-Nov-89	0.00	238.00	1336.00	1321.00	1090.00	385.00	822.00	837.00	1364.00	86.00	7479.00	46.72	19.39	22.18	5.66	3				32
Campground)	09-Nov-89	0.00	206.00	1893.00	1248.00	877.00	292.00	630.00	644.00	1070.00	45.00	6905.00	38.83	16.15	18.45	7.63	3				32
Campground)	09-Nov-89	0.00	142.00	1590.00	1347.00	1150.00	327.00	689.00	773.00	1377.00	24.00	7419.00	43.00	18.88	19.71	6.26	3				32
Campground)	09-Nov-89	0.00	0.00	1513.00	2448.00	654.00	130.00	233.00	91.00	978.00	50.00	6107.00	24.43	17.00	5.31	9.59	4				32
Campground)	09-Nov-89	0.00	0.00	1524.00	2167.00	972.00	202.00	288.00	161.00	810.00	45.00	6169.00	24.41	13.86	7.28	9.89	4				32
Campground)	09-Nov-89	0.00	0.00	1450.00	1632.00	960.00	217.00	383.00	312.00	718.00	36.00	5708.00	29.19	13.21	12.18	9.07	4				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	0.00	1222.00	1696.00	1549.00	441.00	693.00	460.00	1061.00	12.00	7134.00	37.38	15.04	16.16	7.05	1				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	0.00	1143.00	1549.00	1310.00	369.00	639.00	513.00	1229.00	14.00	6766.00	40.85	18.37	17.03	6.22	1				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	433.00	320.00	1283.00	1418.00	406.00	678.00	546.00	1804.00	51.00	6939.00	50.22	26.73	17.64	4.35	1				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	773.00	1335.00	1312.00	1242.00	392.00	742.00	652.00	384.00	10.00	6852.00	31.96	5.75	20.49	10.85	2				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	1954.00	1089.00	925.00	974.00	373.00	771.00	779.00	746.00	121.00	7732.00	36.08	11.21	20.05	10.28	2				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	403.00	2039.00	1136.00	1040.00	319.00	629.00	615.00	380.00	47.00	6608.00	30.12	6.46	18.83	11.22	3				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	934.00	1952.00	1473.00	1243.00	326.00	458.00	265.00	612.00	15.00	7278.00	23.03	8.62	9.93	13.36	3				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	0.00	1259.00	1752.00	1697.00	392.00	471.00	244.00	696.00	256.00	6767.00	30.43	14.07	10.57	7.43	3				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	1321.00	1081.00	1621.00	1246.00	348.00	694.00	656.00	478.00	12.00	7457.00	29.34	6.57	18.10	11.77	4				32
Blackfoot R. (Dalton)	05-Nov-88	0.00	737.00	1329.00	1714.00	1140.00	358.00	350.00	639.00	514.00	8.00	6789.00	27.53	7.69	14.57	11.29	5				32
Campground)	07-Nov-88	0.00	0.00	121.00	1905.00	2351.00	548.00	752.00	434.00	622.00	136.00	6869.00	36.28	11.04	17.27	6.19	1				32
Campground)	07-Nov-88	0.00	0.00	1924.00	1407.00	1195.00	400.00	751.00	746.00	1103.00	57.00	7583.00	40.31	15.30	19.74	7.04	1				32
Campground)	07-Nov-88	0.00	0.00	959.00	1565.00	1236.00	411.00	822.00	473.00	600.00	92.00	6158.00	38.94	11.24	21.03	7.13	1				32
Campground)	07-Nov-88	0.00	0.00	2212.00	1518.00	977.00	310.00	604.00	616.00	558.00	52.00	6857.00	31.35	9.04	17.79	9.85	2				32
Campground)	07-Nov-88	0.00	655.00	1198.00	1780.00	1102.00	306.00	656.00	747.00	859.00	41.00	7344.00	35.53	12.25	19.10	8.51	3				32
Campground)	07-Nov-88	0.00	139.00	1280.00	1622.00	1491.00	450.00	794.00	834.00	606.00	43.00	7259.00	37.57	8.94	22.43	7.84	3				32
Campground)	07-Nov-88	0.00	153.00	1090.00	1802.00	1219.00	375.00	716.00	641.00	1044.00	43.00	7083.00	39.80	15.35	19.16	6.79	3				32
Campground)	07-Nov-88	0.00	120.00	1412.00	2921.00	1300.00	230.00	406.00	384.00	1115.00	78.00	7966.00	27.78	14.98	9.92	8.61	4				32
Campground)	07-Nov-88	0.00	0.00	1225.00	1794.00	1496.00	313.00	353.00	172.00	859.00	47.00	6259.00	27.96	14.48	8.39	8.46	4				32
Campground)	07-Nov-88	0.00	0.00	1327.00	2490.00	965.00	131.00	299.00	177.00	677.00	57.00	6135.00	22.03	12.13	7.76	10.27	4				32
Blackfoot (D-4)	05-Nov-86	863.00	358.00	1366.00	1229.00	1098.00	321.00	609.00	478.00	966.00	53.00	7341.00	33.06	13.88	14.81	10.21	1	Dalton Bridge			32
Blackfoot (D-4)	05-Nov-86	0.00	287.00	575.00	1517.00	1339.00	396.00	670.00	332.00	1536.00	55.00	5717.00	44.50	23.69	14.92	5.25	1				32
Blackfoot (D-4)	05-Nov-86	0.00	580.00	1190.00	1312.00	1151.00	319.00	703.00	441.00	890.00	57.00	6753.00	35.59	14.02	16.94	8.45	1				32
Blackfoot (D-4)	05-Nov-86	0.00	0.00	1272.00	1728.00	598.00	55.00	40.00	28.00	901.00	77.00	4699.00	23.43	20.81	1.45	8.91	2	Hogum Bridge			32
Blackfoot (D-4)	05-Nov-86	0.00	504.00	1198.00	1571.00	403.00	45.00	51.00	24.00	639.00	130.00	4565.00	19.47	16.88	1.64	11.68	2				32
Blackfoot (D-4)	05-Nov-86	0.00	186.00	1158.00	1352.00	763.00	215.00	505.00	481.00	351.00	113.00	5134.00	32.43	9.04	19.21	9.07	2				32
Blackfoot (D-4)	05-Nov-86	0.00	288.00	1711.00	1253.00	982.00	258.00	599.00	300.00	950.00	26.00	6367.00	33.50	15.33	14.12	8.81	3	At Moose Crk			32
Blackfoot (D-4)	05-Nov-86	0.00	822.00	1535.00	1418.00	867.00	219.00	442.00	264.00	1053.00	34.00	6654.00	30.24	16.34	10.61	9.92	3				32
Blackfoot (D-4)	05-Nov-86	0.00	206.00	1171.00	1656.00	1020.00	316.00	650.00	402.00	888.00	27.00	6356.00	36.08	14.40	16.71	7.88	3				32
Lump Gulch	07-Aug-03	0.00	568.90	672.50	354.90	267.70	78.90	186.80	234.70	86.80	1.30	2452.50	24.00	3.59	17.19	16.48	1	8N	5W	24	27
Lump Gulch	07-Aug-03	0.00	527.60	53.60	23.00	76.90	55.00	225.30	503.60	194.10	3.30	1662.40	59.03	11.87	43.85	6.41	2	8N	5W	24	27
Lump Gulch	07-Aug-03	0.00	0.00	330.40	349.30	831.40	234.20	480.00	665.40	179.20	3.60	3073.50	50.83	5.95	37.27	5.58	3	8N	5W	24	27
Lump Gulch	29-Jul-03	0.00	0.00	873.60	760.70	522.50	249.40	648.20	430.00	603.00	13.50	4101.00	47.41	15.04	26.29	6.30	1	9N	4W	35	29

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Snowbank Creek	08-Oct-03	0.00	0.00	746.10	716.10	506.10	217.00	431.70	473.20	303.40	10.70	3404.30	42.18	9.23	26.58	7.47	3				25
Copper Creek	08-Oct-03	0.00	0.00	772.00	994.30	732.40	253.80	624.30	754.10	439.80	9.60	4580.30	45.45	9.81	30.09	6.55	1				25
Lump Gulch	29-Jul-03	0.00	247.60	397.70	320.90	296.90	105.40	208.60	199.00	194.20	2.70	1973.00	35.98	9.98	20.66	9.65	3	9N	4W	36	29
Lump Gulch	29-Jul-03	0.00	0.00	125.30	833.80	517.00	186.10	449.00	533.80	862.50	41.20	3548.70	58.40	25.47	27.69	3.48	3	9N	4W	36	29
Lump Gulch	29-Jul-03	0.00	0.00	905.20	594.40	297.60	76.50	196.50	168.60	408.50	8.90	2656.20	32.34	15.71	13.75	8.99	4	9N	4W	36	29
Lump Gulch	29-Jul-03	0.00	0.00	1434.30	1127.40	403.40	156.50	243.70	297.00	288.10	6.30	4056.70	26.91	7.26	15.79	11.93	2	9N	4W	36	29
Lump Gulch	29-Jul-03	0.00	0.00	110.20	373.50	290.70	129.50	423.80	488.20	780.00	69.10	2665.00	70.94	31.86	34.22	2.39	5	9N	4W	36	29
Ten Mile Creek	14-Aug-03	0.00	274.70	340.90	320.90	235.80	65.50	144.40	213.20	167.00	2.40	1764.80	33.57	9.60	20.26	10.32	Site 1				22
Ten Mile Creek	14-Aug-03	0.00	0.00	559.40	646.60	472.00	138.80	377.20	776.20	260.70	3.80	3234.70	48.13	8.18	35.65	6.16	Site 2				22
Ten Mile Creek	14-Aug-03	0.00	0.00	550.10	922.80	533.80	163.40	438.90	640.70	198.40	1.80	3449.90	41.83	5.80	31.29	7.41	Site 3				22
Ten Mile Creek	14-Aug-03	0.00	0.00	354.00	545.50	414.10	160.50	396.70	477.70	87.50	0.80	2436.80	46.09	3.62	35.88	7.08	Site 4				22
Ten Mile Creek	14-Aug-03	0.00	0.00	63.20	678.50	242.80	68.00	134.50	195.20	224.30	3.20	1609.70	38.84	14.13	20.48	6.34	Site 5				22
Ten Mile Creek	14-Aug-03	0.00	0.00	787.30	669.90	403.30	114.30	223.40	247.70	70.40	0.80	2517.10	26.09	2.83	18.72	12.17	Site 6				22
Creek	28-Jul-03	0.00	404.00	1129.60	335.10	322.30	145.60	440.00	629.00	697.00	41.10	4143.70	47.12	17.81	25.80	6.80	Site 1				11
Creek	28-Jul-03	0.00	0.00	0.00	61.90	178.20	130.40	795.70	838.70	336.30	3.70	2344.90	89.76	14.50	69.70	2.30	Site 2				11
Creek	28-Jul-03	0.00	0.00	478.30	316.70	204.60	90.90	403.30	532.30	517.70	10.00	2553.80	60.86	20.66	36.64	4.14	Site 3				11
Creek	28-Jul-03	0.00	0.00	131.50	21.30	43.40	86.30	998.30	1196.60	532.90	6.00	3016.30	93.50	17.87	72.77	2.08	Site 4				11
Creek	28-Jul-03	0.00	668.10	595.40	355.50	313.90	159.00	616.80	800.00	531.50	11.20	4051.40	52.29	13.40	34.97	6.67	Site 5				11
Creek	28-Jul-03	0.00	0.00	0.00	191.00	302.70	328.30	1271.20	455.80	504.10	28.30	3081.90	83.98	17.29	56.04	2.79	Site 5				11
Copper Creek	08-Oct-03	0.00	840.70	906.00	460.50	441.70	143.50	326.60	305.20	185.30	10.10	3629.60	26.82	5.40	17.45	14.87	5				25
Copper Creek	08-Oct-03	0.00	502.90	1508.50	505.40	324.70	110.80	287.40	227.40	152.10	11.80	3631.00	21.74	4.51	14.18	17.10	4				25
Copper Creek	08-Oct-03	0.00	2000.00	1113.70	391.60	305.30	99.80	279.40	490.80	181.30	10.30	4872.20	21.79	3.93	15.81	20.80	8				25
Copper Creek	08-Oct-03	0.00	1107.80	1017.80	679.20	331.00	98.60	189.10	226.50	196.90	17.80	3864.70	18.86	5.56	10.75	18.90	4				25
Copper Creek	08-Oct-03	0.00	125.60	1082.10	1143.30	804.00	305.80	692.00	495.00	327.40	18.90	4894.10	36.83	6.93	23.77	8.99	3				25
Copper Creek	08-Oct-03	0.00	281.00	907.50	1115.80	684.50	193.20	377.90	408.50	399.60	30.00	4398.00	32.04	9.77	17.88	9.50	6				25
Copper Creek	08-Oct-03	0.00	1130.90	780.30	771.00	552.80	197.70	416.70	439.30	161.60	11.20	4461.50	27.49	3.87	19.19	14.63	7				25
Copper Creek	08-Oct-03	0.00	1007.20	595.10	641.00	607.10	245.90	501.90	521.80	394.60	9.60	4524.20	37.00	8.93	22.63	10.36	2				25
Snowbank Creek	08-Oct-03	0.00	980.70	848.70	352.20	225.50	65.90	193.40	354.10	312.50	10.40	3353.40	28.22	9.63	16.62	14.49	4				25
Snowbank Creek	08-Oct-03	0.00	1463.00	517.20	480.30	428.80	153.40	359.90	455.00	260.80	6.90	4135.30	30.13	6.47	19.95	14.52	1				25
Carpenter Creek	16-Sep-03	0.00	322.20	125.70	480.20	322.20	147.50	344.00	356.10	753.10	43.10	2894.10	56.80	27.51	24.19	4.09	5				27
Carpenter Creek	16-Sep-03	0.00	0.00	181.60	374.30	279.50	104.60	612.60	847.00	311.00	14.60	2725.20	68.35	11.95	53.56	3.58	4				27
Spotted Dog Creek	02-Sep-03	0.00	0.00	521.10	741.00	286.20	119.40	305.20	449.60	351.80	14.40	2788.70	44.48	13.13	27.07	6.49	9				29
Spotted Dog Creek	02-Sep-03	0.00	0.00	663.30	887.50	751.60	219.70	458.50	318.90	136.90	10.40	3495.80	34.16	5.64	22.23	8.93	7				29
Spotted Dog Creek	02-Sep-03	0.00	253.20	848.70	425.00	348.60	118.90	246.00	242.60	252.80	12.20	2743.00	31.81	9.66	17.81	10.92	6				29
Spotted Dog Creek	02-Sep-03	0.00	0.00	872.70	680.00	509.00	149.70	337.40	369.80	267.10	11.30	3207.00	35.40	8.68	22.05	8.81	3				29
Spotted Dog Creek	02-Sep-03	0.00	304.40	1107.80	685.30	457.10	121.90	260.20	264.70	282.30	12.50	3496.20	26.93	8.43	15.01	12.23	1				29
Spotted Dog Creek	02-Sep-03	0.00	0.00	903.70	489.20	352.60	104.80	233.70	260.90	189.20	8.10	2552.20	31.22	7.73	19.38	10.43	4				29
Spotted Dog Creek	02-Sep-03	0.00	0.00	287.80	273.20	500.60	135.30	316.20	312.90	176.40	6.60	2009.00	47.16	9.11	31.31	6.02	10				29
Spotted Dog Creek	02-Sep-03	0.00	0.00	552.80	598.50	378.00	124.20	303.30	417.50	270.70	13.20	2658.20	42.47	10.68	27.12	7.00	5				29
Spotted Dog Creek	02-Sep-03	0.00	321.20	636.70	461.40	477.80	114.30	289.80	416.00	180.80	3.50	2601.50	34.62	6.35	24.33	10.07	8				29
Spotted Dog Creek	02-Sep-03	0.00	612.80	560.80	532.10	408.20	137.40	304.90	299.10	161.00	9.20	3025.50	30.13	5.63	19.95	12.68	2				29
Poorman Creek	16-Jun-03	0.00	0.00	113.50	406.40	381.00	109.90	193.40	123.70	39.20	2.30	1369.40	34.21	3.03	23.16	8.46	6				29
Poorman Creek	16-Jun-03	0.00	0.00	555.00	575.90	349.50	90.60	153.40	159.80	213.70	28.10	2126.00	30.37	11.37	14.73	9.01	2				29
Poorman Creek	16-Jun-03	0.00	0.00	601.50	559.60	334.50	59.70	107.80	127.30	61.30	3.20	1854.90	19.37	3.48	12.67	13.55	7				29
Poorman Creek	16-Jun-03	0.00	0.00	189.30	452.00	491.40	178.00	326.10	161.90	171.90	29.60	2000.20	43.37	10.07	24.40	6.34	1				29
Poorman Creek	16-Jun-03	0.00	0.00	604.20	543.10	303.80	97.40	199.60	194.70	150.90	7.50	2101.20	30.94	7.54	18.77	10.09	3				29
Poorman Creek	16-Jun-03	0.00	0.00	634.70	514.00	313.30	95.80	211.10	243.60	136.20	5.60	2154.30	32.14	6.58	21.11	9.98	4				29
Poorman Creek	16-Jun-03	0.00	0.00	80.90	377.30	797.40	243.30	327.50	149.30	51.30	8.60	2035.60	38.32	2.94	23.42	7.27	8				29
Poorman Creek	16-Jun-03	0.00	161.40	1096.50	811.30	349.00	92.20	165.00	124.80	33.50	2.90	2835.60	14.75	1.28	10.22	18.20	5				29
Poorman Creek	16-Jun-03	0.00	0.00	398.00	720.10	341.30	89.20	131.20	87.20	112.30	8.70	1888.00	22.70	6.41	11.57	11.35	4				29
Snowbank Creek	08-Oct-03	0.00	357.20	958.90	871.30	533.40	171.20	283.00	260.80	143.80	5.70	3587.30	24.10	4.17	15.16	13.72	5				25
Snowbank Creek	08-Oct-03	0.00	0.00	918.90	722.20	801.40	237.90	482.20	406.90	410.50	8.60	3968.60	38.45	10.56	21.90	7.74	1				25
Snowbank Creek	08-Oct-03	0.00	1011.10	456.30	553.40	261.00	80.40	237.40	331.30	309.30	10.00	3250.20	29.80	9.82	17.50	13.27	2				25
Shingle Mill Creek	23-Oct-03	0.00	0.00	1059.30	650.10	416.40	145.50	260.30	153.50	45.00	3.80	2733.90	22.24	1.78	15.14	14.53	5				3
Shingle Mill Creek	23-Oct-03	0.00	0.00	1261.90	480.90	441.50	148.60	334.80	226.30	75.70	3.30	2983.00	26.44	2.65	18.81	13.46	1				3
Shingle Mill Creek	23-Oct-03	0.00	0.00	1138.70	740.10	642.10	214.60	397.40	199.90	75.70	6.00	3414.50	26.17	2.39	17.49	12.64	6				3

Helena National Forest McNeil Core Database (continued)

Stream Name	Date	76,2 mm Sieve (Grams)	50,8 mm Sieve (Grams)	25,4 mm Sieve (Grams)	12,7 mm Sieve (Grams)	6,3 mm Sieve (Grams)	4,76 mm Sieve (Grams)	2,38 mm Sieve (Grams)	0,85 mm Sieve (Grams)	0,074 mm Sieve (Grams)	<0,074 mm (Grams)	Total Weight of Sample (Grams)	% Fines	% Fine Sediment (Reiser & White 1988)	%Coarse Sediment (Reiser & White 1988)	Geometric Mean	Site	Township	Range	Section	Riparian Aggregate
Shingle Mill Creek	23-Oct-03	0.00	0.00	194.80	989.30	431.70	376.40	178.00	363.10	31.90	2.40	2567.60	37.07	1.34	21.07	8.89	3				3
Shingle Mill Creek	23-Oct-03	0.00	0.00	507.70	778.30	526.50	172.00	388.50	342.60	195.90	9.10	2920.60	37.94	7.02	25.03	8.07	2				3
Shingle Mill Creek	23-Oct-03	0.00	243.00	934.70	786.50	640.00	223.00	481.90	84.20	123.60	7.60	3524.50	26.11	3.72	16.06	13.17	4				3
Trout Creek	25-Jun-03	0.00	0.00	97.80	533.10	747.50	218.10	387.00	415.30	358.20	15.70	2772.70	50.29	13.49	28.94	4.80	1				
Arrastra Creek	16-Jun-03	0.00	549.50	837.20	809.70	548.10	147.40	248.80	205.50	120.10	4.80	3471.10	20.93	3.60	13.09	15.47	4				
Arrastra Creek	16-Jun-03	0.00	154.40	1146.20	705.80	396.00	124.30	268.60	344.30	238.70	10.00	3388.30	29.10	7.34	18.09	11.54	3				
Arrastra Creek	16-Jun-03	0.00	172.30	215.00	668.40	464.00	144.70	227.30	257.30	413.20	13.90	2576.10	41.01	16.58	18.81	6.47	5				
Arrastra Creek	16-Jun-03	1138.70	0.00	239.80	392.10	332.40	114.50	227.10	241.70	150.90	7.50	2844.70	26.07	5.57	16.48	18.81	6				
Arrastra Creek	16-Jun-03	0.00	0.00	933.40	769.30	527.50	152.40	299.20	376.20	193.10	4.50	3255.60	31.50	6.07	20.75	10.05	2				
Arrastra Creek	16-Jun-03	0.00	0.00	565.90	662.20	443.60	147.90	307.30	355.60	262.80	7.60	2752.90	39.27	9.82	24.08	7.64	1				
Carpenter Creek	16-Sep-03	0.00	670.70	522.80	543.80	252.30	117.50	307.40	398.50	583.50	26.30	3422.80	41.87	17.82	20.62	7.97	1				27
Carpenter Creek	16-Sep-03	0.00	295.60	580.40	324.70	440.40	171.10	516.70	435.80	530.20	19.80	3314.70	50.49	16.59	28.74	6.06	2				27
Carpenter Creek	16-Sep-03	0.00	371.10	44.80	348.30	302.60	89.00	223.80	279.60	424.40	19.80	2103.40	49.28	21.12	23.93	5.51	5				27
Carpenter Creek	16-Sep-03	0.00	0.00	156.40	379.90	272.00	130.60	593.40	759.70	657.60	19.30	2968.90	72.77	22.80	45.58	2.82	3				27

Core Indicator Values for Percent Fines from McNeil Cores Collected in the Lake Helena TPA

Tables 3 and 4. McNeil Core Data from Helena National Forest Reference Cores with Riparian Landtype Aggregates Matching Lake Helena 303(d)-Listed Streams

(Data from All Aggregates Combined 3, 6, 10, 11, 12, 24, 25, 26, 27, 28, 29, 31, and 32*)

%Fines		*% Fine Fines*	
Mean	32.74	Mean	10.03
Standard Error	0.41	Standard Error	0.22
Median	32.39	Median	9.78
Mode	#N/A	Mode	#N/A
Standard Deviation	9.97	Standard Deviation	5.26
Sample Variance	99.48	Sample Variance	27.69
Kurtosis	0.53	Kurtosis	0.09
Skewness	0.25	Skewness	0.54
Range	66.90	Range	30.05
Minimum	5.87	Minimum	0.73
Maximum	72.77	Maximum	30.78
Sum	19119.88	Sum	5859.09
Count	584.00	Count	584.00
Confidence Level(95.0%)	0.81	Confidence Level(95.0%)	0.43

* Riparian aggregate 32 was collected off the HNF, and thus does not have an official designation in the landtype aggregate descriptions. It is alluvial outwash, floodplains and terraces.

Figure 1.

Distribution of Percent Fines < 6.4 mm for All Helena National Forest Reference Riparian Landtype Aggregates

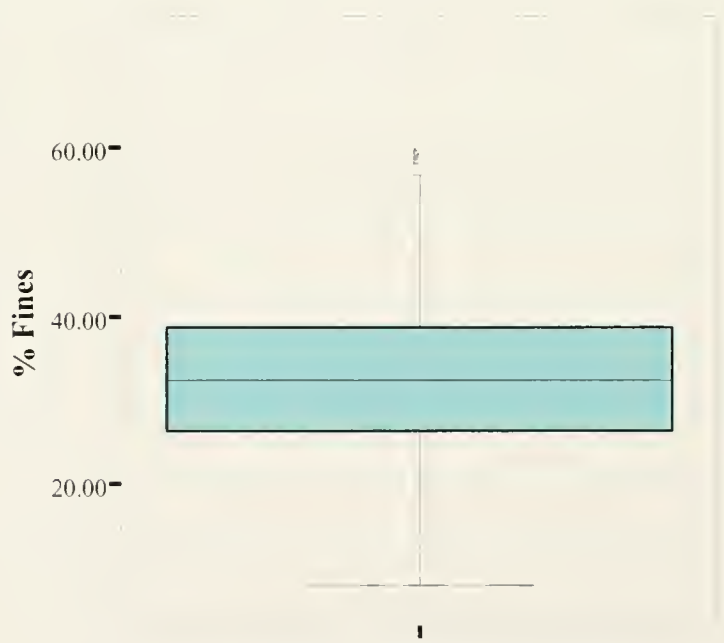
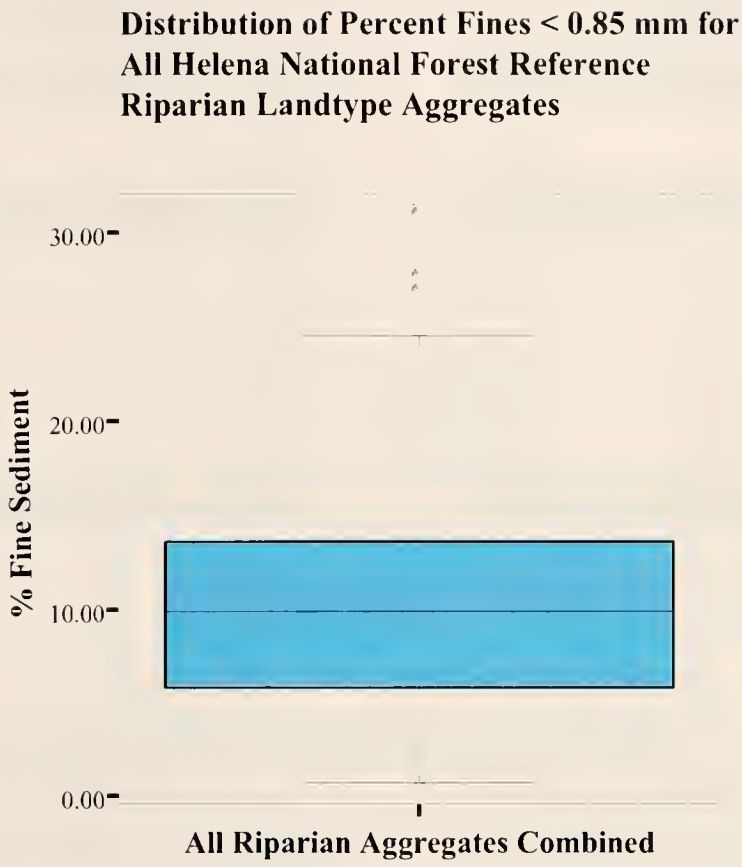


Figure 2.



Tables 5 and 6. Riparian Aggregates 3: Metasedimentary Rock, Mountain Slopes and Ridges, and 19: Metasedimentary Rock, Rolling Uplands

% Fines	
Mean	35.17
Standard Error	0.94
Median	34.10
Mode	#N/A
Standard Deviation	10.22
Sample Variance	104.40
Kurtosis	-0.34
Skewness	0.24
Range	48.58
Minimum	10.49
Maximum	59.07
Sum	4114.97
Count	117.00
Confidence Level(95.0%)	1.87

% Fine Fines	
Mean	8.52
Standard Error	0.48
Median	7.90
Mode	#N/A
Standard Deviation	5.20
Sample Variance	27.07
Kurtosis	1.78
Skewness	1.08
Range	29.45
Minimum	1.32
Maximum	30.78
Sum	997.29
Count	117.00
Confidence Level(95.0%)	0.95

Tables 7 and 8. Riparian Aggregates 10: Granitic Rock, Mountain Slopes and Ridges, and 11: Granitic Rock, Rolling Uplands

% Fines	
Mean	35.76
Standard Error	1.61
Median	35.17
Mode	#N/A
Standard Deviation	8.82
Sample Variance	77.73
Kurtosis	0.13
Skewness	0.78
Range	34.06
Minimum	21.39
Maximum	55.45
Sum	1072.67
Count	30.00
Confidence Level(95.0%)	3.29

% Fine Fines	
Mean	10.15
Standard Error	0.99
Median	9.21
Mode	#N/A
Standard Deviation	5.42
Sample Variance	29.40
Kurtosis	0.31
Skewness	0.72
Range	22.01
Minimum	2.41
Maximum	24.43
Sum	304.64
Count	30.00
Confidence Level(95.0%)	2.02

Tables 9 and 10. Riparian Aggregate 27: Friable Loamy Glacial Till, Moraines

% Fines	
Mean	56.76
Standard Error	4.94
Median	53.64
Mode	#N/A
Standard Deviation	12.10
Sample Variance	146.35
Kurtosis	-1.52
Skewness	0.36
Range	30.90
Minimum	41.87
Maximum	72.77
Sum	340.56
Count	6.00
Confidence Level(95.0%)	12.70

% Fine Fines	
Mean	19.63
Standard Error	2.21
Median	19.47
Mode	#N/A
Standard Deviation	5.40
Sample Variance	29.18
Kurtosis	-0.05
Skewness	0.07
Range	15.56
Minimum	11.95
Maximum	27.51
Sum	117.79
Count	6.00
Confidence Level(95.0%)	5.67

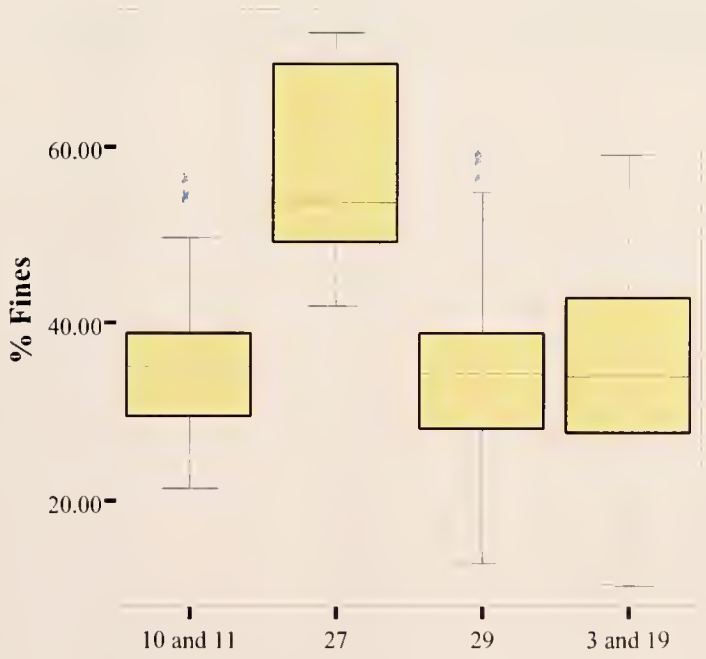
Tables 11 and 12. Riparian Aggregate 29: Alluvial (Borolls), Floodplains and Terraces

% Fines	
Mean	33.85
Standard Error	1.09
Median	34.18
Mode	#N/A
Standard Deviation	9.74
Sample Variance	94.86
Kurtosis	0.32
Skewness	0.28
Range	45.62
Minimum	12.89
Maximum	58.52
Sum	2708.14
Count	80.00
Confidence Level(95.0%)	2.17

% Fine Fines	
Mean	8.12
Standard Error	0.39
Median	8.45
Mode	#N/A
Standard Deviation	3.45
Sample Variance	11.93
Kurtosis	-0.55
Skewness	0.09
Range	15.00
Minimum	1.18
Maximum	16.18
Sum	649.74
Count	80.00
Confidence Level(95.0%)	0.77

Figure 3.

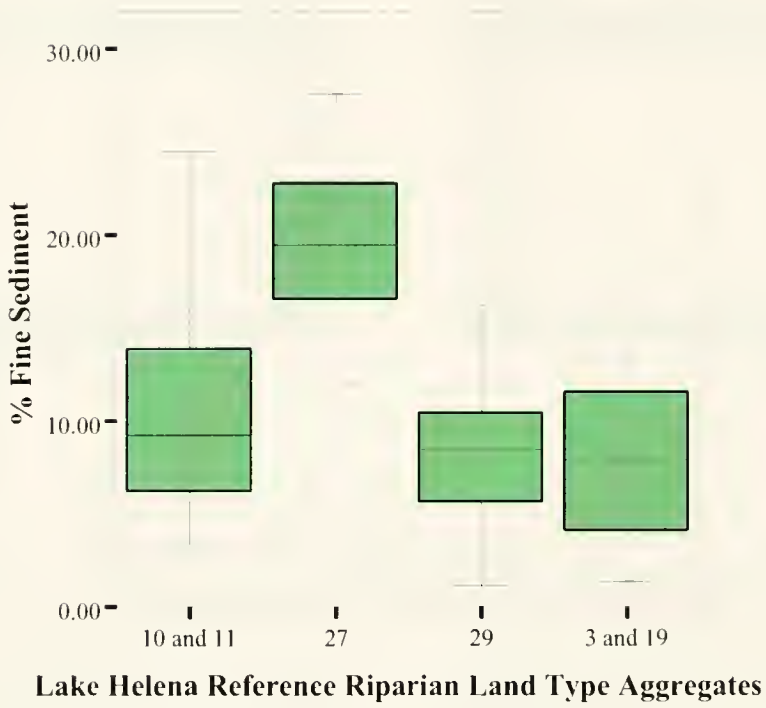
Distribution of Percent Fines < 6.4 mm for Matched Helena National Forest Reference Riparian Landtype Aggregates



Lake Helena Reference Riparian Land Type Aggregates

Figure 4.

Distribution of Percent Fines < 0.85 mm for Matched Helena National Forest Reference Riparian Landtype Aggregates



McNeil Core Data for Sediment Listed Streams in the Lake Helena TPA

Table 13. Summary of Mc Neil Core Data Collected on Sediment Listed Streams in the Lake Helena TPA

Segment_ID	Stream Order	Aggregate	Geology	% Fines mean	% Fines median	% Fines 95% conf mean	% Fine Sediment mean	% Fine Sediment median	% Fine Sediment 95% conf
MT41I006_120	2nd	18	Cretaceous volcanic rocks	30.45	32.72	8.74	7.39	7.16	4.23
MT41I006_070	2nd	11	Boulder batholith and broadly related rocks	35.64	37.96	13.83	12.42	11.08	7.31
MT41I006_210	1st	10	Boulder batholith and broadly related rocks	41.24	39.06	11.85	16.31	15.89	8.09
MT41I006_020	5th	29	Alluvium	42.28	41.99	9.15	10.50	10.50	1.74
MT41I006_030	5th	29	Alluvium	25.32	23.07	6.82	6.14	6.10	1.39
MT41I006_050	5th	29	Boulder batholith and broadly related rocks	30.24	30.89	5.29	10.20	10.68	1.92
MT41I006_080	4th	29	Boulder batholith and broadly related rocks	69.63	64.85	13.36	21.17	16.97	10.67
MT41I006_143	4th	29	Alluvium	25.08	24.34	6.31	7.22	6.87	1.93
MT41I006_110	4th	29	Boulder batholith and broadly related rocks	39.90	36.02	17.57	12.89	12.85	0.82
MT41I006_120	4th	29/11	Boulder batholith and broadly related rocks	49.65	52.56	11.44	17.48	18.72	5.02
MT41I006_190	2nd	10	Boulder batholith and broadly related rocks	38.55	37.71	12.51	13.31	11.02	7.05
MT41I006_130	4th	29	Boulder batholith and broadly related rocks	45.48	41.87	17.63	17.84	15.52	9.60
MT41I006_143	5th	29	Alluvium	26.46	26.10	7.27	10.43	10.66	4.33
MT41I006_040	5th	29	Tertiary sedimentary rocks, undifferentiated	28.29	26.59	6.56	9.29	8.68	3.24
MT41I006_220	3rd	29/19	Cambrian, undifferentiated	41.40	41.69	12.30	15.98	16.65	5.54
MT41I006_160	4th	29	Alluvium	41.00	41.00	40.85	15.81	15.81	20.27
MT41I006_142	3rd	29	Cretaceous volcanic rocks	37.99	32.41	18.44	10.30	9.59	4.48
MT41I006_130		unk - 27	Boulder batholith and broadly related rocks	51.45	51.42	1.77	17.69	19.10	4.09
MT41I006_130	2nd	27	Boulder batholith and broadly related rocks	44.62	50.83	45.52	7.14	5.95	10.60
MT41I006_100	2nd	11	Boulder batholith and broadly related rocks	39.95	38.20	17.33	15.44	14.86	8.31
MT41I006_060	2nd	25	Boulder batholith and broadly related rocks	30.80	29.29	6.36	11.58	11.46	3.76
MT41I006_100	2nd	11	Boulder batholith and broadly related rocks	71.25	72.42	21.24	16.92	17.55	2.74
MT41I006_060	2nd	unk - 25, 26	Boulder batholith and broadly related rocks	37.62	33.86	7.86	11.50	11.34	4.59
MT41I006_141	3rd	22	Boulder batholith and broadly related rocks	39.09	40.34	8.63	7.36	6.99	4.41
MT41I006_220		3	Cretaceous volcanic rocks	36.42	35.69	3.97	14.04	12.67	6.30

Helena National Forest Reference Stream Dataset

Contact the Helena National Forest for more information on their Valley Bottom Inventory Database

Table 14. Reference Dataset from Helena National Forest Streams

Rosgen Stream Type 1	Rosgen Stream Type 2	Date	Stream Name	Stream Order	Riparian Aggregate	Geology	Sinuosity	Bankfull Gradient	Width/Depth Ratio	Entrenchment Ratio	D50	D84
A3		28-Jul-92	South Fork Warm Springs Creek	2nd	11	Boulder batholith and broadly related rocks	1.02	7.60	8.45	1.11	very coarse gravels - small cobbles	medium boulders
A3		28-Jun-00	Trib. to Sauerkraut Creek	2nd	5	Belt Series - Newland limestone	1.18	8.40	10.60	1.73	small cobbles	small boulders
A3 or B3a		20-Jul-00	Little Camas	3rd	38313	Belt Series - Newland limestone	1.10	4.19	14.00	1.19	small cobble	large cobble
A3a+		30-Sep-03	Ruby Creek	2	24	Boulder batholith and broadly related rocks	1.09	15.53	12.84	1.60	Small Cobbles	Small Boulders
A4		23-Oct-03	Shingle Mill Creek	2nd	3	Belt Series - Missoula group	1.15	6.40	7.50	1.52	Very coarse gravels	Large cobbles
A4		21-Jul-99	No Grass Creek	1st	25	Cretaceous volcanic rocks	1.16	6.22	10.70	1.54	very coarse gravels	large cobbles
A4		30-Jul-97	Washington Creek	1st	9/4 stream runs b/n two agg.	Belt Series - Missoula group	1.07	0.08	10.80	1.68	very coarse gravels	small cobbles
A4		21-Jul-97	Gleason Creek	2nd	3	Belt Series - Missoula group	1.12	7.98	9.08	2.21	very coarse gravels	large cobbles
A4		29-Jun-99	Hurd Creek	1st	2	Tertiary volcanic rocks	1.35	8.22	5.30	2.31	medium gravels	small cobbles
A4 or B4		16-Sep-97	Clear Creek (lower)	1st	3	Belt Series - Newland limestone	1.24	3.60	9.52	3.68	coarse gravel	small cobble
A4?		09-Sep-97	Clear Creek	1st	3	Belt Series - Newland limestone	1.10	7.90	8.70	2.72	coarse gravel	small cobble
A4a+		01-Jul-99	Spotted Dog Creek (upper central trib.)	1st	2	Cretaceous volcanic rocks	1.22	14.00	6.50	1.98	coarse gravels	small cobbles
B3		07-Oct-03	South Fork Warm Springs Creek	2nd	11	Boulder batholith and broadly related rocks	1.08	3.40	19.27	1.17	small cobbles	small boulders
B3 or C3b (doesn't fit)		13-Jul-00	Trib. to Big Birch	1st	24	Tertiary sedimentary rocks, undifferentiated	1.28	2.24	9.00	1.20	small cobble	large cobble
B3a	B3	26-Jul-99	Little Blackfoot	3rd	25	Cretaceous volcanic rocks	1.16	3.46	15.40	1.33	small cobble	large cobble
B3a or A3 ?		15-Jul-97	Gleason Creek	2nd	3	Belt Series - Missoula group	1.21	8.60		1.57	small cobbles	small boulders
B3a or B2?	A3	04-Aug-98	Ontario Creek	3rd	30	Cretaceous volcanic rocks	1.13	4.70	13.40	1.28	large cobble	small boulder
B3a or B4a	A3 or A4	14-Jul-98	Upper Monarch Creek	1st	2	Tertiary volcanic rocks	1.27	5.60	8.02	4.08	very coarse gravel	small cobble

Reference Dataset from Helena National Forest Streams (continued)

Rosgen Stream Type 1	Rosgen Stream Type 2	Date	Stream Name	Stream Order	Riparian Aggregate	Geology	Sinuosity	Bankfull Gradient	Width/Depth Ratio	Entrenchment Ratio	D50	D84
B4		02-Jul-92	Holloway (Upper)	1st	20	Belt Series - Newland limestone	1.21	14.60	3.90	2.45	small gravels	large boulders
B4		06-Aug-98	Little Blackfoot	3rd	30	Cretaceous volcanic rocks	1.05	2.40	15.06	1.43	coarse gravel	small boulder
B4		09-Sep-99	Little Blackfoor (upper)	2nd	25	Cretaceous volcanic rocks	1.34	1.98	11.60	2.06	coarse gravels	small cobbles
B4		16-Jul-97	Gleason Creek	2nd	16 or b/n 3 & 16	Belt Series - Missoula group	1.24	2.20	9.38	6.79	very coarse gravels	large cobbles
B4		21-Oct-03	Dutchman Creek	2nd	11	Boulder batholith and broadly related rocks	1.14	3.51	12.64	1.25	Very fine gravels	Medium boulders
B4a	A4	08-Jul-98	Larabee Gulch	2nd	28	Cretaceous volcanic rocks	1.10	4.50	15.38	1.52	coarse gravels	large cobbles
B4a		21-Aug-97	Wasson Creek	1st	5	Belt Series - Ravalli group	1.24	4.00	3.70	1.80	fine gravels	very coarse gravels
E4		22-Oct-03	Walker Creek	2nd	27	Cretaceous volcanic rocks	1.27	1.26	7.63	1.21	Very fine gravels	Coarse gravels
E4b		01-Oct-03	Upper Tenmile	1	24	Boulder batholith and broadly related rocks	1.43	2.24	5.18	1.00	coarse gravels	small cobbles
E5		02-Aug-99	Bison Creek	2nd	28	Boulder batholith and broadly related rocks	1.35	1.00	3.62	7.66	medium sand	coarse gravels
E5		17-Aug-99	W. Fork Bison	2nd	2	Boulder batholith and broadly related rocks	1.30	1.39	2.20	6.27	very coarse sand	small cobbles

Southwest Montana and the Greater Yellowstone Area Reference Stream Dataset

Table 15. Reference Dataset from Southwestern Montana and Greater Yellowstone Area Streams

Sytream Type	Count	Entrenchment (Measured)	Width/Depth (Measured)	Sinuosity	Grade	D50	D84	BEHI
Average A3's	10					127.56	374.01	
Average A's	11	1.29	8.67	1.11	7.60			21.06
Average B3's	29					94.13	248.81	
Average B4's	19					39.99	152.88	
Average B's	48	1.68	13.43	1.26	3.60			20.49
Average C3's	15					94.11	210.57	
Average C4's	21					38.17	104.65	
Average C5's	2					0.28	11.46	
Average C's	38	9.90	21.21	1.47	1.00			20.32
Average E3's	21				4.24	86.97	231.53	
Average E4's	85				2.44	24.60	73.40	
Average E5's	20				2.56	0.90	50.21	
Average E6's	5				0.90	0.37	7.92	
Average E's	131	20.05	3.94	1.48	2.50			18.77

The full dataset and above summary were acquired from the Pete Bengeyfield in July of 2003. Pete is a hydrologist with the Beaverhead Deerlodge National Forest in Dillon, MT. His work is published in the conference proceedings of Science Into Policy: Water in the Public Realm / Wildland Hydrology, pp. 245 -254. Held in Bozeman, Montana, June 30 - July 2, 1999. Available online at http://www.deq.state.mt.us/wqinfo/monitoring/Publications/wildlandhydrology2.html

Channel Cross-Section Data for Sediment Listed Streams in the Lake Helena TPA

Table 16. Summary of Cross-Sectional Data for 303(d) Listed Streams, Part 1

Stream Name	Segment_ID	Date	Length of stream surveyed (feet)	Sinuosity (Ave)	Average Bankfull Width (feet)	Average Floodplain Width (feet)	Bankfull Gradient (percent)	Average Bankfull Depth (feet)	Width/Depth ratio	D50	D84	Entrenchment	Rosgen Stream Type 1	Rosgen Stream Type 2
Prickly Pear	MT41I006_060	8/12/2003	300	1.21	13.47	24.8	10	1.6	7.5	Small Boulders	Large Boulders		A2a+	
Prickly Pear below Alhambra	MT41I006_050	8/25/2003	300	1	25.9	46	1	1.4	18.4	Coarse Gravels	Very Coarse Gravels	1.7	B4c	C4 straightened, incised or F4
Prickly Pear below McCellan Ck conf.	MT41I006_040	9/11/2003	300	1	35.8	40.3	0.5	1.18	30.5	Very Coarse Gravels	Small Cobbles	>1.7	C4 straightened	F4
Prickly Pear below E. Helena	MT41I006_030	8/26/2003	300	1.1	17	19.9	1	0.56	30.4	Very Coarse Gravels	Small Cobbles	1.3	F4	C4 straightened, incised
Prickly Pear @ Canyon Ferry Road	MT41I006_030	8/26/2003	300	1	31.6		0.2	0.67	47.2	Coarse Gravels	Very Coarse Gravels	>3.4	C4 straightened	
Prickly Pear above Tenmile	MT41I006_020	9/11/2003	300	1.1	32	35.5	0.3	1.9	16.8	Very Coarse Sand	Fine Gravels	1.1	F5	straightened, incised C5
Golconda Creek abv private road	MT41I006_070	8/13/2003	300	1.2	6.3	9.4	5	0.67	9.4	Very Coarse Gravels	Large Cobbles	1.5	B4a	
Corbin Creek near RR tressle	MT41I006_090	8/13/2003	300	1.2	13.3	17.6	4	0.43	30.9	Coarse Sand	Medium Gravels	1.5	B5a	
Spring Creek in pasture above road crossing	MT41I006_080	8/14/2003	300	1.1	5.3	11.5	2.4	0.55	9.6	Fine Gravels	Coarse Gravel	4.4	?	E4b straightened
Middle Fork Warm Springs Creek	MT41I006_100	7/28/2003	400	1.14	6.175	13.5	3.5	0.68	7.34	Very Coarse Sand	Small Cobbles		B5 or G5	
North Fork Warm Springs Creek	MT41I006_180	8/13/2003	300	1.19	3.53	10.23	4.56	0.13	16.15	Very Fine Gravels	Large Cobbles		B4a	
Warm Springs Creek below Loop Road	MT41I006_110	8/15/2003	300	1.3	11.7	17.3	2	0.68	17.2	Coarse Gravels	Small Cobbles	2.5	C4	
Clancy Creek below headwaters sample site	MT41I006_120	8/14/2003	300	1.1	4.6	10.1	2.5	0.47	9.8	Coarse Gravels	Very Coarse Gravels	2.2	B4	
Clancy Creek below Mushroon growing facility	MT41I006_120	8/15/2003	300	1.2	12.8	28.7	0.4	0.46	28	Fine Gravels	Coarse Gravels	2.2	B4c	F4
Lump Gulch	MT41I006_130	8/7/2003	300	1.3	9.43	24.33	6.15	0.695	21.31	Very Coarse Gravels	Small Boulders		B4a	
Lump Gulch below Little Buffalo	MT41I006_130	7/29/2003	300	1.1	13.8	26.6	1.75	1.13	12.2	Fine Gravels	Small Cobbles	1.9	B4c	
Jackson Creek near mouth	MT41I006_190	8/25/2003	300	1.1	8.3	10.4	8	0.53	15.7	Coarse Gravels	Large Cobbles	1.4	B4a	
Upper Tenmile	MT41I006_141	10/1/2003	300	1.43	3.73	3.73	2.24	0.69	5.184	Coarse Gravels	Small Cobbles		E4b	
Tenmile above Banner	MT41I006_141	8/14/2003	400	1.17	21.6	28.58	2.2	0.73	23.83	Small Cobbles	Small Boulders		B3	B3a
Tenmile below Bear Gulch conf.	MT41I006_142	9/9/2003	300	1.1	26.7	30.9	0.7	1.69	15.8	Very Coarse Gravels	Large Cobbles	1.2	F4	
Tenmile above mouth of Sevenmile	MT41I006_143	8/27/2003	300	1.1	23.7	28.3	0.5	0.6	39.5	Coarse Gravels	Very Coarse Gravels	1.1	F4	C4 straightened, incised
Tenmile below Sevenmile	MT41I006_143	9/9/2003	300	1	21	30.2	0.7	0.84	25	Very Coarse Gravels	Small Cobbles	2.2	C4 straightened	
Skelly Gulch d/s of Jeff Davis Gulch	MT41I006_220	9/10/2003	300	1.5	9.1	11.9	3.6	0.67	13.6	Medium Gravels	Very Coarse Gravels	1.3	C4b	
Sevenmile Creek near mouth	MT41I006_160	8/27/2003	300	1.1	15.1	25.5	0.5	1.6	9.4	Medium Gravels	Very Coarse Gravels	1.8	?	B4c
Jennie's Fork below ski area	MT41I006_210	9/10/2003	300	1.2	1.7	2.4	14	0.4	4.3	Medium Gravels	Small Cobbles	1.4	A4a+	

Table 17. Summary of Cross-Sectional Data for 303(d) Listed Streams, Part 2

Stream Name	Segment_ID	Date	Stream Order	Riparian Aggregate	Deposition	Geology	BEHI score (Avg)	PFC	PFC qualifier
Prickly Pear	MT41I006_060	8/12/2003	2nd	27	some deposition and pool infilling	Boulder batholith and broadly related rocks	Low (boulder dominated)	PFC	
Prickly Pear below Alhambra	MT41I006_050	8/25/2003	5th	29	pool infilling	Boulder batholith and broadly related rocks	25.4 Moderate	NF	roads
Prickly Pear below McCellan Ck conf.	MT41I006_040	9/11/2003	5th	29	pool infilling	Tertiary sedimentary rocks, undifferentiated	21.7 Moderate	F@R	roads
Prickly Pear below E. Helena	MT41I006_030	8/26/2003	5th	29	excessive sediment	Alluvium	18 Low	NF	agriculture, upstream impacts
Prickly Pear @ Canyon Ferry Road	MT41I006_030	8/26/2003	5th	29		Alluvium	22.3 Moderate	NF	agriculture, upstream impacts
Prickly Pear above Tenmile	MT41I006_020	9/11/2003	5th	29		Alluvium	37.3 High	NF	agriculture, roads, upstream impacts
Golconda Creek abv private road	MT41I006_070	8/13/2003	2nd	11		Boulder batholith and broadly related rocks	23.7 Moderate	PFC	
Corbin Creek near RR tressle	MT41I006_090	8/13/2003	2nd	11	excessive fines	Boulder batholith and broadly related rocks	38.6 High	NF	mining, roads, grazing
Spring Creek in pasture above road crossing	MT41I006_080	8/14/2003	4th	29/11	excessive fines	Boulder batholith and broadly related rocks	29.6 Moderate/High	NF	mining, grazing, upstream impacts
Middle Fork Warm Springs Creek	MT41I006_100	7/28/2003	2nd	11	some aggradation	Boulder batholith and broadly related rocks	12.7 Low	F@R	impacted by and recovering from historic mining, impacted by roads
North Fork Warm Springs Creek	MT41I006_180	8/13/2003	2nd	11	pool infilling and sand	Boulder batholith and broadly related rocks	24 Moderate	F@R	impacted by roads
Warm Springs Creek below Loop Road	MT41I006_110	8/15/2003	4th	29/11	pool infilling	Boulder batholith and broadly related rocks	26.3 Moderate	F@R	development, upstream impacts
Clancy Creek below headwaters sample site	MT41I006_120	8/14/2003	2nd	18		Cretaceous volcanic rocks	23.5 Moderate	NF	mining, roads, grazing
Clancy Creek below Mushroon growing facility	MT41I006_120	8/15/2003	4th	29/11		Boulder batholith and broadly related rocks	22.9 Moderate	NF	mining, roads, grazing
Lump Gulch	MT41I006_130	8/7/2003	2nd	27	some deposition	Boulder batholith and broadly related rocks	21.0 Moderate	F@R	impacted by and recovering from historic mining
Lump Gulch below Little Buffalo	MT41I006_130	7/29/2003	4th	29	deposition	Boulder batholith and broadly related rocks	21.5 Moderate	F@R	roads, upstream impacts
Jackson Creek near mouth	MT41I006_190	8/25/2003	2nd	10	excessive sediment	Boulder batholith and broadly related rocks	21.2 Moderate	PFC	sediment inputs natural from burn
Upper Tenmile	MT41I006_141	10/1/2003	2nd	24		Boulder batholith and broadly related rocks	Low	PFC	
Tenmile above Banner	MT41I006_141	8/14/2003	3rd	22	excessive sediment	Boulder batholith and broadly related rocks	Low (boulder dominated)	F@R	impacted by historic mining
Tenmile below Bear Gulch conf.	MT41I006_142	9/9/2003	3rd	29	pool infilling	Cretaceous volcanic rocks	11.2 Low	F@R	municipal water withdrawls, upstream impacts
Tenmile above mouth of Sevenmile	MT41I006_143	8/27/2003	4th	29	excessive sediment	Alluvium	25.7 Moderate	F@R	agriculture, roads, upstream impacts
Tenmile below Sevenmile	MT41I006_143	9/9/2003	5th	29	excessive sediment	Alluvium	36.4 High	F@R/NF	agriculture, roads, upstream impacts
Skelly Gulch d/s of Jeff Davis Gulch	MT41I006_220	9/10/2003	3rd	29/19		Cambrian, undifferentiated	24.7 Moderate	PFC	
Sevenmile Creek near mouth	MT41I006_160	8/27/2003	4th	29	siltation	Alluvium	37.1 High	F@R	agriculture, upstream impacts
Jennie's Fork below ski area	MT41I006_210	9/10/2003	1st	10	excessive sediment	Boulder batholith and broadly related rocks	22.7 Moderate	F@R	roads, developed rec, mining

Suspended Sediment and Suspended Solids Data for Sediment Listed Streams in the Lake Helena TPA

Refer to Tables 3-14, 3-17, 3-20, 3-39, 3-47, 3-42, 3-55, 3-58, 3-63, and 3-66 in section 3.0, of the ***Water Quality Restoration Plan and Total Maximum Daily Loads (TMDLs) for the Lake Helena Watershed TMDL Planning Area: Volume 1 – Watershed Characterization and Water Quality Status Review***

Appendix G: Metals Data for Impairment Status Determination

Table 1. Summary of metals data used for impairment status determination

Note: All concentrations are in ug/L

Segment \ID	Segment Name	Parameter Code	Parameter Description	Min Date	Max Date	Min Value	Max Value	Avg Value	Count	Below Det.	Total Exceeding	AL_Acute Criterion	AL_Chronic Criterion	Human Health Criterion	Exceeding AL_Acute	Exceeding AL_Chronic	Exceeding Human Health	AL_Acute or Human Health Exceedances?	Percent of samples exceeding AL_Chronic Criterion	Ratio of Max Value to AL_Chronic Criterion	Ratio of Max Value to Human Health Criterion	% Diff. of Avg Value and AL_Acute Criterion	% Diff. of Avg Value and AL_Chronic Criterion	% Diff of Avg Value and Human Health Criterion	Impairment Determination
MT41I006_020	PRICKLY PEAR CREEK from Helena WWTP Discharge Ditch to Lake Helena	01002	Arsenic	17-Jul-03	12-Aug-03	13	22	17.5	2	0	2	340.0	150.0	10.0	0	0	2	Yes	0.0%	0.1	2.2	-94.9%	-88.3%	75.0%	Impaired
MT41I006_020	PRICKLY PEAR CREEK from Helena WWTP Discharge Ditch to Lake Helena	01027	Cadmium	17-Jul-03	12-Aug-03	0.4	0.9	0.7	2	0	1	5.2	0.5	5.0	0	1	0	No	50.0%	1.8	0.2	-87.5%	28.2%	-87.0%	Impaired
MT41I006_020	PRICKLY PEAR CREEK from Helena WWTP Discharge Ditch to Lake Helena	01042	Copper	17-Jul-03	12-Aug-03	2	8	5.0	2	0	0	31.0	18.9	1300.0	0	0	0	No	0.0%	0.4	0.0	-83.8%	-73.6%	-99.6%	Not impaired
MT41I006_020	PRICKLY PEAR CREEK from Helena WWTP Discharge Ditch to Lake Helena	01051	Lead	17-Jul-03	12-Aug-03	7	26	16.5	2	0	1	238.5	9.2	15.0	0	1	1	Yes	50.0%	2.8	1.7	-93.1%	78.4%	10.0%	Impaired
MT41I006_020	PRICKLY PEAR CREEK from Helena WWTP Discharge Ditch to Lake Helena	01092	Zinc	17-Jul-03	12-Aug-03	26	67	46.5	2	0	0	249.9	249.9	2000.0	0	0	0	No	0.0%	0.3	0.0	-81.4%	-81.4%	-97.7%	Not impaired
MT41I006_030	PRICKLY PEAR CREEK from Highway 433 Crossing to Helena WWTP Discharge	01002	Arsenic	16-Jul-03	12-Aug-03	19	30	24.5	4	0	4	340.0	150.0	10.0	0	0	4	Yes	0.0%	0.2	3.0	-92.8%	-83.7%	145.0%	Impaired
MT41I006_030	PRICKLY PEAR CREEK from Highway 433 Crossing to Helena WWTP Discharge	01027	Cadmium	16-Jul-03	12-Aug-03	0.2	0.2	0.2	4	0	0	2.5	0.3	5.0	0	0	0	No	0.0%	0.7	0.0	-91.9%	-32.1%	-96.0%	Not impaired
MT41I006_030	PRICKLY PEAR CREEK from Highway 433 Crossing to Helena WWTP Discharge	01042	Copper	16-Jul-03	12-Aug-03	2	2	2.0	4	0	0	15.5	10.1	1300.0	0	0	0	No	0.0%	0.2	0.0	-87.1%	-80.3%	-99.8%	Not impaired
MT41I006_030	PRICKLY PEAR CREEK from Highway 433 Crossing to Helena WWTP Discharge	01051	Lead	16-Jul-03	12-Aug-03	4	5	4.5	4	0	4	93.9	3.6	15.0	0	4	0	No	100.0%	1.4	0.3	-95.2%	23.6%	-70.0%	Impaired
MT41I006_030	PRICKLY PEAR CREEK from Highway 433 Crossing to Helena WWTP Discharge	01092	Zinc	16-Jul-03	12-Aug-03	14	24	19.0	4	0	0	133.9	133.9	2000.0	0	0	0	No	0.0%	0.2	0.0	-85.8%	-85.8%	-99.1%	Not impaired
MT41I006_040	PRICKLY PEAR CREEK from Lump Gulch to Montana Highway 433 Crossing	01002	Arsenic	04-Jun-99	12-Aug-03	4	30	11.4	20	0	7	340.0	150.0	10.0	0	0	7	Yes	0.0%	0.2	3.0	-96.6%	-92.4%	14.5%	Impaired
MT41I006_040	PRICKLY PEAR CREEK from Lump Gulch to Montana Highway 433 Crossing	01027	Cadmium	04-Jun-99	12-Aug-03	0.1	1.19	0.3	20	3	5	2.0	0.3	5.0	0	5	0	No	25.0%	4.6	0.2	-82.9%	35.4%	-93.0%	Impaired
MT41I006_040	PRICKLY PEAR CREEK from Lump Gulch to Montana Highway 433 Crossing	01042	Copper	04-Jun-99	12-Aug-03	1.7	20.2	5.3	20	0	4	13.1	8.7	1300.0	3	4	0	Yes	20.0%	2.3	0.0	-59.3%	-38.8%	-99.6%	Impaired
MT41I006_040	PRICKLY PEAR CREEK from Lump Gulch to Montana Highway 433 Crossing	01051	Lead	04-Jun-99	12-Aug-03	1	54	11.9	20	2	14	74.4	2.9	15.0	0	14	4	Yes	70.0%	18.7	3.6	-84.0%	312.7%	-20.6%	Impaired
MT41I006_040	PRICKLY PEAR CREEK from Lump Gulch to Montana Highway 433 Crossing	01092	Zinc	04-Jun-99	12-Aug-03	14	216	88.6	20	0	6	114.6	114.6	2000.0	6	6	0	Yes	30.0%	1.9	0.1	-22.7%	-22.7%	-95.6%	Impaired
MT41I006_050	PRICKLY PEAR CREEK from Spring Cr to Lump Gulch	01002	Arsenic	14-Jun-00	19-Aug-03	1	8	3.6	23	2	0	340.0	150.0	10.0	0	0	0	No	0.0%	0.1	0.8	-98.9%	-97.6%	-64.1%	Not impaired
MT41I006_050	PRICKLY PEAR CREEK from Spring Cr to Lump Gulch	01027	Cadmium	14-Jun-00	19-Aug-03	0.07	0.685	0.4	23	0	18	2.2	0.3	5.0	0	18	0	No	78.3%	2.5	0.1	-82.1%	45.7%	-92.0%	Impaired
MT41I006_050	PRICKLY PEAR CREEK from Spring Cr to Lump Gulch	01042	Copper	14-Jun-00	19-Aug-03	1	7.7	2.9	23	0	0	14.2	9.3	1300.0	0	0	0	No	0.0%	0.8	0.0	-79.8%	-69.4%	-99.8%	Not impaired
MT41I006_050	PRICKLY PEAR CREEK from Spring Cr to Lump Gulch	01051	Lead	14-Jun-00	19-Aug-03	0.1	19	3.1	23	5	5	83.0	3.2	15.0	0	5	1	Yes	21.7%	5.9	1.3	-96.3%	-4.8%	-79.6%	Impaired
MT41I006_050	PRICKLY PEAR CREEK from Spring Cr to Lump Gulch	01092	Zinc	14-Jun-00	19-Aug-03	48	249	128.3	23	0	12	123.3	123.3	2000.0	12	12	0	Yes	52.2%	2.0	0.1	4.0%	4.0%	-93.6%	Impaired
MT41I006_060	PRICKLY PEAR CREEK from headwaters to Spring Cr	01002	Arsenic	16-Oct-00	18-Aug-03	0.427	3	1.5	11	5	0	340.0	150.0	10.0	0	0	0	No	0.0%	0.0	0.3	-99.5%	-99.0%	-84.6%	Not impaired
MT41I006_060	PRICKLY PEAR CREEK from headwaters to Spring Cr	01027	Cadmium	16-Oct-00	18-Aug-03	0.02	0.114	0.1	11	6	0	0.9	0.1	5.0	0	0	0	No	0.0%	0.8	0.0	-90.6%	-40.7%	-98.4%	Not impaired
MT41I006_060	PRICKLY PEAR CREEK from headwaters to Spring Cr	01042	Copper	16-Oct-00	18-Aug-03	0.9	3.1	1.4	11	2	0	6.0	4.3	1300.0	0	0	0	No	0.0%	0.7	0.0	-76.1%	-66.6%	-99.9%	Not impaired
MT41I006_060	PRICKLY PEAR CREEK from headwaters to Spring Cr	01051	Lead	16-Oct-00	18-Aug-03	0.864	2	1.1	11	8	1	25.8	1.0	15.0	0	1	0	No	9.1%	2.0	0.1	-95.8%	7.6%	-92.8%	Impaired
MT41I006_060	PRICKLY PEAR CREEK from headwaters to Spring Cr	01092	Zinc	16-Oct-00	18-Aug-03	1	10	4.6	11	3	0	56.3	56.3	2000.0	0	0	0	No	0.0%	0.2	0.0	-91.9%	-91.9%	-99.8%	Not impaired
MT41I006_070	GOLCONDA CREEK, Headwaters to the mouth (Prickly Pear Cr) T 7N, R3W	01002	Arsenic	16-Oct-00	18-Aug-03	1	2	1.3	4	2	0	340.0	150.0	10.0	0	0	0	No	0.0%	0.0	0.2	-99.6%	-99.2%	-87.5%	Not impaired
MT41I006_070	GOLCONDA CREEK, Headwaters to the mouth (Prickly Pear Cr) T 7N, R3W	01027	Cadmium	16-Oct-00	18-Aug-03	0.17	0.3	0.2	4	0	4	0.8	0.1	5.0	0	4	0	No	100.0%	2.3	0.1	-73.5%	63.8%	-95.7%	Impaired
MT41I006_070	GOLCONDA CREEK, Headwaters to the mouth (Prickly Pear Cr) T 7N, R3W	01042	Copper	16-Oct-00	18-Aug-03	1	1.9	1.4	4	1	0	5.6	4.1	1300.0	0	0	0	No	0.0%	0.5	0.0	-76.1%	-66.8%	-99.9%	Not impaired
MT41I006_070	GOLCONDA CREEK, Headwaters to the mouth (Prickly Pear Cr) T 7N, R3W	01051	Lead	16-Oct-00	18-Aug-03	3	15	6.8	4	0	4	23.9	0.9	15.0	0	4	0	No	100.0%	16.2	1.0	-71.8%	627.2%	-55.0%	Impaired
MT41I006_070	GOLCONDA CREEK, Headwaters to the mouth (Prickly Pear Cr) T 7N, R3W	01092	Zinc	16-Oct-00	18-Aug-03	22	42	30.8	4	0	0	53.7	53.7	2000.0	0	0	0	No	0.0%	0.8	0.0	-42.7%	-42.7%	-98.5%	Not impaired
MT41I006_080	SPRING CREEK from Corbin Cr to the mouth (Prickly Pear Cr)	01002	Arsenic	16-Oct-00	11-Aug-03	5.01	32	16.0	4	0	3	340.0	150.0	10.0	0	0	3	Yes	0.0%	0.2	3.2	-95.3%	-89.3%	60.0%	Impaired
MT41I006_080	SPRING CREEK from Corbin Cr to the mouth (Prickly Pear Cr)	01027	Cadmium	16-Oct-00	11-Aug-03	0.8	2	1.4	4	0	4	7.6	0.7	5.0	0	4	0	No	100.0%	3.0	0.4	-81.5%	111.0%	-71.8%	Impaired
MT41I006_080	SPRING CREEK from Corbin Cr to the mouth (Prickly Pear Cr)	01042	Copper	16-Oct-00	11-Aug-03	4.04	57	22.4	4	0	1	44.1	26.1	1300.0	1	1	0	Yes	25.0%	2.2	0.0	-49.1%	-13.9%	-98.3%	Impaired
MT41I006_080	SPRING CREEK from Corbin Cr to the mouth (Prickly Pear Cr)	01051	Lead	16-Oct-00	11-Aug-03	8.08	124	49.8	4	0	2	384.4	14.9	15.0	0	2	2	Yes	50.0%	8.3	8.3	-87.1%	234.0%	231.8%	Impaired
MT41I006_080	SPRING CREEK from Corbin Cr to the mouth (Prickly Pear Cr)	01092	Zinc	16-Oct-00	11-Aug-03	119	352	207.0	4	0	1	344.0	344.0	2000.0	1	1	0	Yes	25.0%	1.0	0.2	-39.8%	-39.8%	-89.7%	Impaired
MT41I006_090	CORBIN CREEK from headwaters to the mouth (Spring Cr)	01002	Arsenic	14-Jul-03	18-Aug-03	1	13	7.0	2	1	1	340.0	150.0	10.0	0	0	1	Yes	0.0%	0.1	1.3	-97.9%	-95.3%	-30.0%	Impaired
MT41I006_090	CORBIN CREEK from headwaters to the mouth (Spring Cr)	01027	Cadmium	14-Jul-03	18-Aug-03	17	59	38.0	2	0	2	15.8	1.1	5.0	2	2	2	Yes	100.0%	52.1	11.8	141.1%	3255.4%	660.0%	Impaired
MT41I006_090	CORBIN CREEK from headwaters to the mouth (Spring Cr)	01042	Copper	14-Jul-03	18-Aug-03	88	767	427.5	2	0	2	85.9	47.7	1300.0	2	2	0	Yes	100.0%	16.1	0.6	397.4%	796.6%	-67.1%	Impaired
MT41I006_090	CORBIN CREEK from headwaters to the mouth (Spring Cr)	01051	Lead	14-Jul-03	18-Aug-03	12	54	33.0	2	0	1	947.8	36.7	15.0	0	1	1	Yes	50.0%	1.5	3.6	-96.5%	-10.2%	120.0%	Impaired
MT41I006_090	CORBIN CREEK from headwaters to the mouth (Spring Cr)	01092	Zinc	14-Jul-03	18-Aug-03	6770	42700	24735.0	2	0	2	629.3	629.3	2000.0	2	2	2	Yes	100.0%	67.9	21.4	3830.8%	3830.8%	1136.8%	Impaired
MT41I006_100	MIDDLE FK WARM SPRINGS CREEK, Headwaters to mouth (Warm Springs Cr - P	01002	Arsenic	14-Jun-00	20-Aug-03	1	87	37.1	27	0	25	340.0	150.0	10.0	0	0	25	Yes	0.0%	0.6	8.7	-89.1%	-75.2%	271.5%	Impaired
MT41I006_100	MIDDLE FK WARM SPRINGS CREEK, Headwaters to mouth (Warm Springs Cr - P	01027	Cadmium	14-Jun-00	20-Aug-03	0.04	11.3	1.4	27	1	26	2.5	0.3	5.0	2	26	1	Yes	96.3%	38.4	2.3	-42.6%	379.6%	-71.8%	Impaired
MT41I006_100	MIDDLE FK WARM SPRINGS CREEK, Headwaters to mouth (Warm Springs Cr - P	01042	Copper	14-Jun-00	20-Aug-03	1	6.8	3.0	27	0	0	15.5	10.1	1300.0	0	0	0	No	0.0%	0.7	0.0	-80.4%	-70.0%	-99.8%	Not impaired
MT41I006_100	MIDDLE FK WARM SPRINGS CREEK, Headwaters to mouth (Warm Springs Cr - P	01051	Lead	14-Jun-00	20-Aug-03	1	30	4.1	27	7	6	93.9	3.6	15.0	0	6	2	Yes	22.2%	8.2	2.0	-95.7%	11.9%	-72.8%	Impaired
MT41I006_100	MIDDLE FK WARM SPRINGS CREEK, Headwaters to mouth (Warm Springs Cr - P	01092	Zinc	14-Jun-00	20-Aug-03	1	3370	368.9	27	0	24	133.9	133.9	2000.0	24	24	1	Yes	88.9%	25.2	1.7	175.4%	175.4%	-81.6%	Impaired
MT41I006_110	WARM SPRINGS CREEK from the Middle Fork to the mouth (Prickly Pear Cr)	01002	Arsenic	11-Oct-00	20-Aug-03	9	16	13.4	8	0	7	340.0	150.0	10.0	0	0	7	Yes	0.0%	0.1	1.6	-96.0%	-91.0%	34.4%	Impaired
MT41I006_110	WARM SPRINGS CREEK from the Middle Fork to the mouth (Prickly Pear Cr)	01027	Cadmium	11-Oct-00	20-Aug-03	0.091	0.3	0.1	8	4	1	1.3	0.2	5.0	0	1	0	No	12.5%	1.6	0.1	-90.0%	-29.7%	-97.4%	Impaired

Segment \ID	Segment Name	Parameter Code	Parameter Description	Min Date	Max Date	Min Value	Max Value	Avg Value	Count	Below Det.	Total Exceeding	AL_Acute Criterion	AL_Chronic Criterion	Human Health Criterion	Exceeding AL_Acute	Exceeding AL_Chronic	Exceeding Human Health	AL_Acute or Human Health Exceedances?	Percent of samples exceeding AL_Chronic Criterion	Ratio of Max Value to AL_Chronic Criterion	Ratio of Max Value to Human Health Criterion	% Diff. of Avg Value and AL_Acute Criterion	% Diff. of Avg Value and AL_Chronic Criterion	% Diff of Avg Value and Human Health Criterion	Impairment Determination
MT41I006_110	WARM SPRINGS CREEK from the Middle Fork to the mouth (Prickly Pear Cr)	01042	Copper	11-Oct-00	20-Aug-03	0.091	2.5	1.1	8	4	0	8.7	6.0	1300.0	0	0	0	No	0.0%	0.4	0.0	-87.6%	-82.0%	-99.9%	Not impaired
MT41I006_110	WARM SPRINGS CREEK from the Middle Fork to the mouth (Prickly Pear Cr)	01051	Lead	11-Oct-00	20-Aug-03	0.592	2	1.3	8	4	1	43.2	1.7	15.0	0	1	0	No	12.5%	1.2	0.1	-97.1%	-24.8%	-91.6%	Impaired
MT41I006_110	WARM SPRINGS CREEK from the Middle Fork to the mouth (Prickly Pear Cr)	01092	Zinc	11-Oct-00	20-Aug-03	1	90	28.5	8	1	1	79.7	79.7	2000.0	1	1	0	Yes	12.5%	1.1	0.0	-64.2%	-64.2%	-98.6%	Impaired
MT41I006_120	CLANCY CREEK from headwaters to the mouth (Prickly Pear Cr)	01002	Arsenic	14-Jun-00	12-Aug-03	4	37	12.8	18	0	7	340.0	150.0	10.0	0	0	7	Yes	0.0%	0.2	3.7	-96.2%	-91.4%	28.4%	Impaired
MT41I006_120	CLANCY CREEK from headwaters to the mouth (Prickly Pear Cr)	01027	Cadmium	14-Jun-00	12-Aug-03	0.06	2	0.5	18	2	6	2.3	0.3	5.0	0	6	0	No	33.3%	7.1	0.4	-79.5%	68.5%	-90.6%	Impaired
MT41I006_120	CLANCY CREEK from headwaters to the mouth (Prickly Pear Cr)	01042	Copper	14-Jun-00	12-Aug-03	1	23	4.5	18	1	2	14.6	9.6	1300.0	2	2	0	Yes	11.1%	2.4	0.0	-69.1%	-52.9%	-99.7%	Impaired
MT41I006_120	CLANCY CREEK from headwaters to the mouth (Prickly Pear Cr)	01051	Lead	14-Jun-00	12-Aug-03	0.529	19	3.0	18	8	3	86.3	3.3	15.0	0	3	1	Yes	16.7%	5.7	1.3	-96.6%	-11.1%	-80.2%	Impaired
MT41I006_120	CLANCY CREEK from headwaters to the mouth (Prickly Pear Cr)	01092	Zinc	14-Jun-00	12-Aug-03	1	319	81.9	18	1	5	126.5	126.5	2000.0	5	5	0	Yes	27.8%	2.5	0.2	-35.3%	-35.3%	-95.9%	Impaired
MT41I006_130	LUMP GULCH from headwaters to the mouth (Prickly Pear Cr)	01002	Arsenic	12-Jun-00	19-Aug-03	0.681	6	2.5	29	10	0	340.0	150.0	10.0	0	0	0	No	0.0%	0.0	0.6	-99.3%	-98.3%	-75.1%	Not impaired
MT41I006_130	LUMP GULCH from headwaters to the mouth (Prickly Pear Cr)	01027	Cadmium	12-Jun-00	19-Aug-03	0.03	3.41	0.5	29	6	12	1.1	0.2	5.0	4	12	0	Yes	41.4%	20.7	0.7	-52.5%	218.5%	-89.5%	Impaired
MT41I006_130	LUMP GULCH from headwaters to the mouth (Prickly Pear Cr)	01042	Copper	12-Jun-00	19-Aug-03	1	5.7	2.2	29	4	2	7.4	5.2	1300.0	0	2	0	No	6.9%	1.1	0.0	-71.0%	-58.6%	-99.8%	Impaired
MT41I006_130	LUMP GULCH from headwaters to the mouth (Prickly Pear Cr)	01051	Lead	12-Jun-00	19-Aug-03	0.1	3	1.1	29	25	3	34.6	1.3	15.0	0	3	0	No	10.3%	2.2	0.2	-96.8%	-17.4%	-92.6%	Impaired
MT41I006_130	LUMP GULCH from headwaters to the mouth (Prickly Pear Cr)	01092	Zinc	12-Jun-00	19-Aug-03	3	1580	178.2	29	1	14	68.6	68.6	2000.0	14	14	0	Yes	48.3%	23.0	0.8	159.8%	159.8%	-91.1%	Impaired
MT41I006_141	TENMILE CREEK, headwaters to the Helena PWS intake above Rimini	01002	Arsenic	14-May-97	27-Sep-01	3	167	17.1	34	7	8	340.0	150.0	10.0	0	1	8	Yes	2.9%	1.1	16.7	-95.0%	-88.6%	71.5%	Impaired
MT41I006_141	TENMILE CREEK, headwaters to the Helena PWS intake above Rimini	01027	Cadmium	14-May-97	27-Sep-01	0.1	30.2	2.3	34	6	28	0.5	0.1	5.0	24	28	3	Yes	82.4%	321.6	6.0	357.6%	2382.1%	-53.4%	Impaired
MT41I006_141	TENMILE CREEK, headwaters to the Helena PWS intake above Rimini	01042	Copper	14-May-97	27-Sep-01	1	200	21.8	34	1	32	3.6	2.7	1300.0	32	32	0	Yes	94.1%	73.2	0.2	498.8%	697.4%	-98.3%	Impaired
MT41I006_141	TENMILE CREEK, headwaters to the Helena PWS intake above Rimini	01051	Lead	14-May-97	27-Sep-01	2	71	7.6	34	5	29	13.2	0.5	15.0	4	29	3	Yes	85.3%	138.6	4.7	-42.1%	1393.0%	-49.0%	Impaired
MT41I006_141	TENMILE CREEK, headwaters to the Helena PWS intake above Rimini	01092	Zinc	14-May-97	27-Sep-01	20	3090	320.4	34	0	30	36.0	36.0	2000.0	30	30	1	Yes	88.2%	85.7	1.5	789.1%	789.1%	-84.0%	Impaired
MT41I006_142	TENMILE CREEK From the Helena PWS intake above Rimini to the Helena WT	01002	Arsenic	15-May-97	18-Jul-03	9	30	20.0	20	0	18	340.0	150.0	10.0	0	0	18	Yes	0.0%	0.2	3.0	-94.1%	-86.7%	100.0%	Impaired
MT41I006_142	TENMILE CREEK From the Helena PWS intake above Rimini to the Helena WT	01027	Cadmium	15-May-97	18-Jul-03	0.6	2.8	1.1	20	3	17	0.9	0.1	5.0	8	17	0	Yes	85.0%	19.4	0.6	19.7%	663.8%	-78.0%	Impaired
MT41I006_142	TENMILE CREEK From the Helena PWS intake above Rimini to the Helena WT	01042	Copper	15-May-97	18-Jul-03	2	88	17.9	20	0	14	6.3	4.5	1300.0	13	14	0	Yes	70.0%	19.7	0.1	185.2%	300.1%	-98.6%	Impaired
MT41I006_142	TENMILE CREEK From the Helena PWS intake above Rimini to the Helena WT	01051	Lead	15-May-97	18-Jul-03	1	13	4.9	20	7	12	27.6	1.1	15.0	0	12	0	No	60.0%	12.2	0.9	-82.2%	358.1%	-67.3%	Impaired
MT41I006_142	TENMILE CREEK From the Helena PWS intake above Rimini to the Helena WT	01092	Zinc	15-May-97	18-Jul-03	94	640	195.5	20	0	20	59.0	59.0	2000.0	20	20	0	Yes	100.0%	10.8	0.3	231.4%	231.4%	-90.2%	Impaired
MT41I006_143	TENMILE CREEK from the Helena WT plant to the mouth (Prickly Pear Cr)	01002	Arsenic	04-Jun-97	04-Dec-03	3	30	15.1	52	1	46	340.0	150.0	10.0	0	0	46	Yes	0.0%	0.2	3.0	-95.6%	-89.9%	51.0%	Impaired
MT41I006_143	TENMILE CREEK from the Helena WT plant to the mouth (Prickly Pear Cr)	01027	Cadmium	04-Jun-97	04-Dec-03	0.06	1.46	0.3	52	2	23	2.3	0.3	5.0	0	23	0	No	44.2%	5.2	0.3	-85.5%	19.5%	-93.3%	Impaired
MT41I006_143	TENMILE CREEK from the Helena WT plant to the mouth (Prickly Pear Cr)	01042	Copper	04-Jun-97	04-Dec-03	1	78.9	7.5	52	2	12	14.7	9.7	1300.0	4	12	0	Yes	23.1%	8.2	0.1	-49.0%	-22.4%	-99.4%	Impaired
MT41I006_143	TENMILE CREEK from the Helena WT plant to the mouth (Prickly Pear Cr)	01051	Lead	04-Jun-97	04-Dec-03	0.06	69.3	4.3	52	19	14	87.2	3.4	15.0	0	14	2	Yes	26.9%	20.5	4.6	-95.0%	28.2%	-71.1%	Impaired
MT41I006_143	TENMILE CREEK from the Helena WT plant to the mouth (Prickly Pear Cr)	01092	Zinc	04-Jun-97	04-Dec-03	1	191	57.4	52	3	6	127.5	127.5	2000.0	6	6	0	Yes	11.5%	1.5	0.1	-55.0%	-55.0%	-97.1%	Impaired
MT41I006_150	SILVER CREEK from headwaters to the mouth (Lake Helena)	01002	Arsenic	01-Aug-01	21-Aug-03	3	23	14.3	4	1	3	340.0	150.0	10.0	0	0	3	Yes	0.0%	0.2	2.3	-95.8%	-90.5%	42.5%	Impaired
MT41I006_150	SILVER CREEK from headwaters to the mouth (Lake Helena)	01027	Cadmium	01-Aug-01	21-Aug-03	0.1	0.1	0.1	4	3	0	6.7	0.6	5.0	0	0	0	No	0.0%	0.2	0.0	-98.5%	-83.6%	-98.0%	Not impaired
MT41I006_150	SILVER CREEK from headwaters to the mouth (Lake Helena)	01042	Copper	01-Aug-01	21-Aug-03	1	18	7.3	4	0	0	39.1	23.4	1300.0	0	0	0	No	0.0%	0.8	0.0	-81.5%	-69.0%	-99.4%	Not impaired
MT41I006_150	SILVER CREEK from headwaters to the mouth (Lake Helena)	01051	Lead	01-Aug-01	21-Aug-03	2	4	2.8	4	2	0	327.4	12.7	15.0	0	0	0	No	0.0%	0.3	0.3	-99.2%	-78.3%	-81.7%	Not impaired
MT41I006_150	SILVER CREEK from headwaters to the mouth (Lake Helena)	01092	Zinc	01-Aug-01	21-Aug-03	1	10	5.5	4	4	0	309.0	309.0	2000.0	0	0	0	No	0.0%	0.0	0.0	-98.2%	-98.2%	-99.7%	Not impaired
MT41I006_160	SEVENMILE CREEK from headwaters to the mouth (Tenmile Cr)	01002	Arsenic	05-Jun-97	04-Dec-03	8	28	15.4	21	0	18	340.0	150.0	10.0	0	0	18	Yes	0.0%	0.2	2.8	-95.5%	-89.7%	53.8%	Impaired
MT41I006_160	SEVENMILE CREEK from headwaters to the mouth (Tenmile Cr)	01027	Cadmium	05-Jun-97	04-Dec-03	0.02	0.9	0.1	21	8	1	5.7	0.5	5.0	0	1	0	No	4.8%	1.7	0.2	-97.8%	-77.2%	-97.5%	Not impaired
MT41I006_160	SEVENMILE CREEK from headwaters to the mouth (Tenmile Cr)	01042	Copper	05-Jun-97	04-Dec-03	1	83	7.9	21	4	2	33.6	20.4	1300.0	1	2	0	Yes	9.5%	4.1	0.1	-76.4%	-61.2%	-99.4%	Impaired
MT41I006_160	SEVENMILE CREEK from headwaters to the mouth (Tenmile Cr)	01051	Lead	05-Jun-97	04-Dec-03	0.46	66.7	4.7	21	13	1	266.2	10.3	15.0	0	1	1	Yes	4.8%	6.5	4.4	-98.2%	-54.8%	-68.9%	Impaired
MT41I006_160	SEVENMILE CREEK from headwaters to the mouth (Tenmile Cr)	01092	Zinc	05-Jun-97	04-Dec-03	1	112	12.5	21	7	0	269.0	269.0	2000.0	0	0	0	No	0.0%	0.4	0.1	-95.4%	-95.4%	-99.4%	Not impaired
MT41I006_180	NORTH FK WARM SPRINGS CREEK, Headwaters to mouth (Warmsprings Cr - Pri	01002	Arsenic	11-Oct-00	12-Aug-03	1	24	5.7	7	1	1	340.0	150.0	10.0	0	0	1	Yes	0.0%	0.2	2.4	-98.3%	-96.2%	-42.9%	Impaired
MT41I006_180	NORTH FK WARM SPRINGS CREEK, Headwaters to mouth (Warmsprings Cr - Pri	01027	Cadmium	11-Oct-00	12-Aug-03	0.02	0.5	0.1	7	4	1	1.8	0.2	5.0	0	1	0	No	14.3%	2.1	0.1	-92.5%	-42.5%	-97.3%	Impaired
MT41I006_180	NORTH FK WARM SPRINGS CREEK, Headwaters to mouth (Warmsprings Cr - Pri	01042	Copper	11-Oct-00	12-Aug-03	1	2.7	1.7	7	0	0	11.7	7.9	1300.0	0	0	0	No	0.0%	0.3	0.0	-85.5%	-78.4%	-99.9%	Not impaired
MT41I006_180	NORTH FK WARM SPRINGS CREEK, Headwaters to mouth (Warmsprings Cr - Pri	01051	Lead	11-Oct-00	12-Aug-03	1	2	1.1	7	6	0	64.3	2.5	15.0	0	0	0	No	0.0%	0.8	0.1	-98.2%	-54.2%	-92.4%	Not impaired
MT41I006_180	NORTH FK WARM SPRINGS CREEK, Headwaters to mouth (Warmsprings Cr - Pri	01092	Zinc	11-Oct-00	12-Aug-03	1	164	24.6	7	4	1	104.0	104.0	2000.0	1	1	0	Yes	14.3%	1.6	0.1	-76.4%	-76.4%	-98.8%	Impaired
MT41I006_210	JENNIES FORK from headwaters to mouth (Silver Cr-Missouri R)	01002	Arsenic	01-Aug-01	21-Aug-03	3	4	3.5	4	0	0	340.0	150.0	10.0	0	0	0	No	0.0%	0.0	0.4	-99.0%	-97.7%	-65.0%	Not impaired
MT41I006_210	JENNIES FORK from headwaters to mouth (Silver Cr-Missouri R)	01027	Cadmium	01-Aug-01	21-Aug-03	0.1	0.1	0.1	4	3	0	3.0	0.3	5.0	0	0	0	No	0.0%	0.3	0.0	-96.6%	-70.4%	-98.0%	Not impaired
MT41I006_210	JENNIES FORK from headwaters to mouth (Silver Cr-Missouri R)	01042	Copper	01-Aug-01	21-Aug-03	1	8	3.0	4	0	0	18.5	11.9	1300.0	0	0	0	No	0.0%	0.7	0.0	-83.8%	-74.7%	-99.8%	Not impaired
MT41I006_210	JENNIES FORK from headwaters to mouth (Silver Cr-Missouri R)	01051	Lead	01-Aug-01	21-Aug-03	1	16	5.5	4	2	1	118.7	4.6	15.0	0	1	1	Yes	25.0%	3.5	1.1	-95.4%	19.5%	-63.3%	Impaired
MT41I006_210	JENNIES FORK from headwaters to mouth (Silver Cr-Missouri R)	01092	Zinc	01-Aug-01	21-Aug-03	10	65	34.8	4	1	0	156.7	156.7	2000.0	0	0	0	No	0.0%	0.4	0.0	-77.8%	-77.8%	-98.3%	Not impaired
MT41I006_220	SKELLY GULCH tributary of Greenhorn Cr-Sevenmile Cr T10N R5W Sec 2	01002	Arsenic	31-Jul-01	20-Aug-03	9	10	9.7	3	0	0	340.0	150.0	10.0	0	0	0	No	0.0%	0.1	1.0	-97.2%	-93.6%	-3.3%	Not impaired

Segment \ID	Segment Name	Parameter Code	Parameter Description	Min Date	Max Date	Min Value	Max Value	Avg Value	Count	Below Det.	Total Exceeding	AL_Acute Criterion	AL_Chronic Criterion	Human Health Criterion	Exceeding AL_Acute	Exceeding AL_Chronic	Exceeding Human Health	AL_Acute or Human Health Exceedances?	Percent of samples exceeding AL_Chronic Criterion	Ratio of Max Value to AL_Chronic Criterion	Ratio of Max Value to Human Health Criterion	% Diff. of Avg Value and AL_Acute Criterion	% Diff. of Avg Value and AL_Chronic Criterion	% Diff of Avg Value and Human Health Criterion	Impairment Determination
MT41I006_220	SKELLY GULCH tributary of Greenhorn Cr-Sevenmile Cr T10N R5W Sec 2	01027	Cadmium	31-Jul-01	20-Aug-03	0.1	0.1	0.1	3	3	0	3.8	0.4	5.0	0	0	0	No	0.0%	0.0	0.0	-97.4%	-75.3%	-98.0%	Not impaired
MT41I006_220	SKELLY GULCH tributary of Greenhorn Cr-Sevenmile Cr T10N R5W Sec 2	01042	Copper	31-Jul-01	20-Aug-03	1	2	1.3	3	2	0	23.2	14.6	1300.0	0	0	0	No	0.0%	0.1	0.0	-94.3%	-90.9%	-99.9%	Not impaired
MT41I006_220	SKELLY GULCH tributary of Greenhorn Cr-Sevenmile Cr T10N R5W Sec 2	01051	Lead	31-Jul-01	20-Aug-03	1	2	1.3	3	3	0	161.8	6.3	15.0	0	0	0	No	0.0%	0.0	0.1	-99.2%	-78.7%	-91.1%	Not impaired
MT41I006_220	SKELLY GULCH tributary of Greenhorn Cr-Sevenmile Cr T10N R5W Sec 2	01092	Zinc	31-Jul-01	20-Aug-03	1	10	4.0	3	3	0	192.8	192.8	2000.0	0	0	0	No	0.0%	0.0	0.0	-97.9%	-97.9%	-99.8%	Not impaired
MT41I007_010	LAKE HELENA	01002	Arsenic	09-Aug-02	29-Aug-03	8	46	24.6	16	0	15	340.0	150.0	10.0	0	0	15	Yes	0.0%	0.3	4.6	-92.8%	-83.6%	145.6%	Impaired
MT41I007_010	LAKE HELENA	01027	Cadmium	09-Aug-02	29-Aug-03	0.1	0.3	0.2	14	3	0	3.7	0.4	5.0	0	0	0	No	0.0%	0.8	0.1	-95.4%	-56.9%	-96.6%	Not impaired
MT41I007_010	LAKE HELENA	01042	Copper	09-Aug-02	29-Aug-03	2	8	3.9	14	0	0	22.8	14.4	1300.0	0	0	0	No	0.0%	0.6	0.0	-83.1%	-73.1%	-99.7%	Not impaired
MT41I007_010	LAKE HELENA	01051	Lead	09-Aug-02	29-Aug-03	2	11	5.9	14	0	6	157.6	6.1	15.0	0	6	0	No	42.9%	1.8	0.7	-96.3%	-4.1%	-61.0%	Impaired
MT41I007_010	LAKE HELENA	01092	Zinc	09-Aug-02	29-Aug-03	5	48	16.9	14	2	0	189.4	189.4	2000.0	0	0	0	No	0.0%	0.3	0.0	-91.1%	-91.1%	-99.2%	Not impaired

Appendix H: SSTEMP Modeling

H.1.0 SSTEMP Modeling Assumptions

The SSTEMP model was chosen to simulate stream temperatures in the suspected thermally impaired segments of Prickly Pear Creek, MT41I006_030 and MT41I006_020. The goals of the SSTEMP modeling were to create realistic temperature models; to ascertain the relative benefits of restoration measures, such as enhancing riparian vegetation; and to evaluate modeling results against naturally occurring temperature for Prickly Pear Creek. Values for the model input parameters were assigned based on available monitoring data or on default parameters suggested in the SSTEMP User's Manual (Bartholow, 2002). This section summarizes the basis for the hydrology, channel geometry, shading, and meteorology modeling assumptions.

H.1.1 Hydrologic Input

For both segments MT41I006_030 and MT41I006_020, values for inflow, inflow temperature, and segment outflow were drawn from actual field data. The date chosen to be modeled was August 7th, 2003, as detailed temperature data existed for these segments from a diel dissolved oxygen and temperature survey.

In segment MT41I006_030, the model was run under the assumption that the stream flowed for the entire length of the segment, and gained 1.5 cfs of flow from the top to the bottom of the segment. Generally the stream is dry in about one half mile of this 4.4 mile segment during the summer irrigation season. Flow data measured during the summer of 2003 when the middle of the segment was dry showed that an average of 1.5 cfs of inflow was gained near the end of the reach. Due to varied water temperatures reflected in available well data for the area, the default accretion value was used in the model (USGS NWIS, 2004). The inflow temperature was taken from the median August temperature recorded on a thermograph deployed in segment MT41I006_040 at East Helena in 2003. Table H-1 lists the input hydrologic values.

For segment MT41I006_020, the model was first run on a 2.6 mile sub-reach of the segment extending from Canyon Ferry Road to Sierra Road in order to calibrate the model. A second model was then run for the entire 5.9 mile length of the segment. Multiple sources of inflow are present within this segment including the City of Helena wastewater treatment plant discharge (WWTP), tile drainage and surplus irrigation water discharges associated with the Helena Valley Irrigation District operations, and ground water discharge. Discharges from the WWTP and irrigation drains tend to be highly variable due to seasonal land application of the wastewater and sporadic irrigation water demands. Flow measurements during the summers of 2003 and 2004 showed that an average of 15 cfs was gained between the site above Stansfield Lake (near the beginning of segment MT41I006_020 and just below York Road)) and the sampling site at Sierra Road. However, observations on August 7th, 2003 indicated that less than half of this gain was occurring. Therefore model input values for inflows to the segment and inflow water temperature were back calculated to achieve the actual measured flows and temperatures at Sierra Road. Input flow and temperature values for the first modeling run were set at 4 cfs and 61 degrees Fahrenheit (^{o} F). For the second model, a gain of 14 cfs was estimated to occur along the entire segment. Due to varied temperatures shown in the available well data for the area, the default accretion value was used in the model (USGS NWIS, 2004). Table H-1 lists the input hydrologic values.

Table H-1. Hydrologic inputs for current conditions in segments MT41I006_030 and MT41I006_020.

Parameter	MT41I006_030	MT41I006_020 - to Sierra Road	MT41I006_020 - entire segment

Segment Inflow (cfs)	1	4	4
Inflow Temperature (°F)	67.5	61	61
Segment Outflow (cfs)	2.5	7.5	18
Accretion Temperature (° F)	55	55	55

H.1.2 Channel Geometry

Topographic maps and GIS layers were used to calculate elevation, aspect, and stream length for segments MT411006_030 and MT411006_020. The Width's A and B term represent the wetted width to discharge relationship, where $W = A*Q^B$ (W = known width, A= untransformed y-intercept of the relationship between the natural log of width versus the natural log of discharge, Q = known discharge, and B = power relationship) (Bartholow, 2002). The Width's A and B term were calculated from 2003 and 2004 channel cross-sectional measurements taken during flow gauging (Figures 1 and 2). Because the relationship tends to break down at low flow levels, only two of three flow measurement runs were used for Prickly Pear Creek at Wylie Drive (one high and one low flow). Manning's n was selected based on the stream segments' geomorphic characteristics. Table H-2 lists the input geometry values.

Figure H-1. Width to flow relationship for MT41I006_030 based on data from the sample site at Wylie Drive.

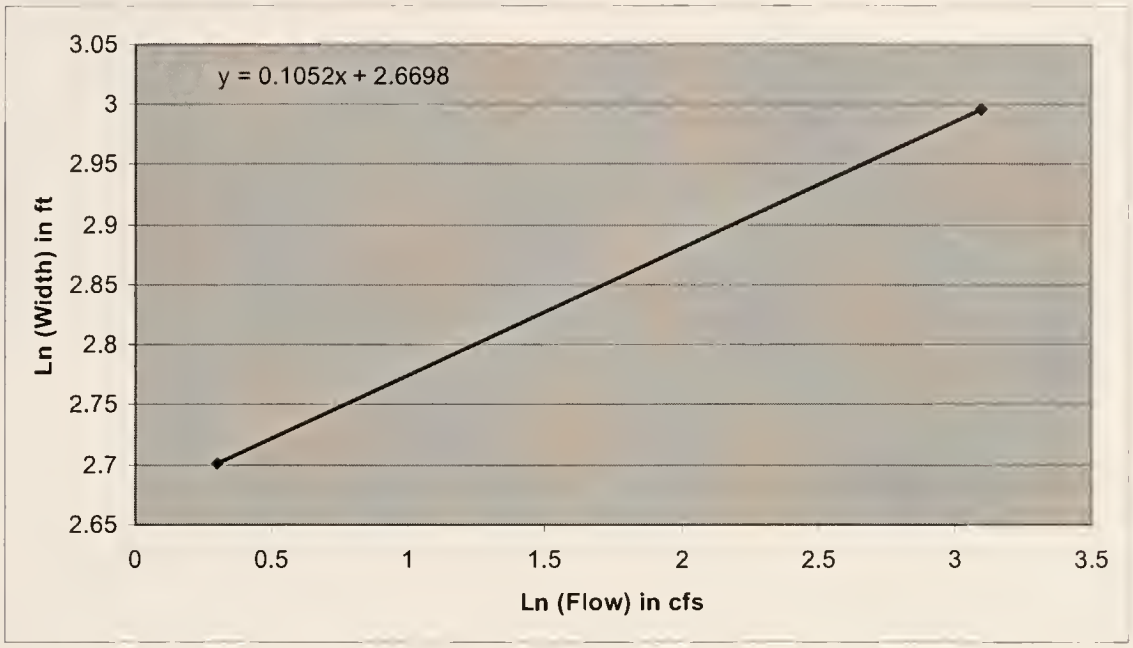


Figure H-2. Width to flow relationship for MT41I006_020 based data from the sample site at Sierra Road.

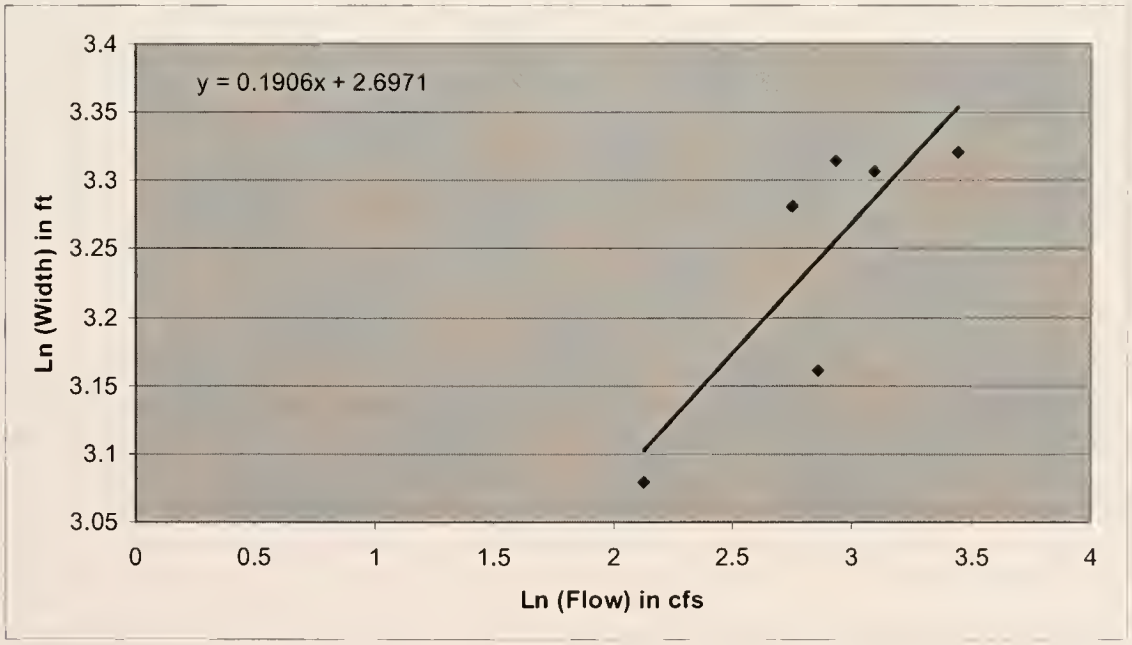


Table H-2. Geometry inputs for segments MT411006_030 and MT411006_020.

Parameter	MT411006_030	MT411006_020 - to Sierra Road	MT411006_020 - entire segment
Latitude (degrees)	46.6	46.7	46.7
Dam at Head of Segment	not checked	not checked	not checked
Segment Length	4.42	2.62	5.92
Upstream Elevation (ft)	3840	3705	3705
Downstream Elevation (ft)	3705	3680	3650
Width's A Term (s/ft^2)	14.4	14.8	14.8
B Term	0.11	0.19	0.19
Manning's n	0.032	0.031	0.030

H.1.3 Optional Shading Variables

Shading variables were adjusted based on a review of aerial photos and field observation, while some default values were kept for segments MT411006_030 and MT411006_020 (Table H-3). The default values were kept for topographic altitude and vegetation height.

Table H-3. Shading inputs for segments MT411006_030 and MT411006_020.

Parameter	MT411006_030		MT411006_020	
Segment Azimuth (degrees)	-45		15	
	West	East	West	East
Topographic Altitude (degrees)	25	15	25	15
Vegetation Height (ft)	25	35	25	35
Vegetation Crown (ft)	10	15	15	10
Vegetation Offset (ft)	5	5	5	5
Vegetation Density (%)	20	60	60	20

H.1.4 Meteorology

Detailed weather data for August 7th, 2003 were acquired for the Helena Regional Airport from the Weather Underground website (2004). Air temperature and relative humidity values were corrected for elevation differences between the weather station and average values for the stream segments (Bartholow, 2002). The default values were used for ground temperature, thermal gradient, possible sun, dust coefficient, and ground reflectivity values. Table H-4 lists the input meteorology values.

Table H-4. Meteorology inputs for segments MT411006_030 and MT411006_020.

Parameter	MT411006_030	MT411006_020
Air Temperature (°F)	78.44	78.73
Maximum Air Temperature (°F)	not checked	not checked
Relative Humidity (%)	32.8	32.5
Wind Speed (mph)	7.1	7.1
Ground Temperature (°F)	55	55
Thermal Gradient ($j/m^2/s/C$)	1.65	1.65
Possible Sun (%)	90	90
Dust Coefficient	5	5
Ground Reflectivity (%)	25	25

H.2.0 SSTEMP Modeling Scenarios

Various SSTEMP modeling runs were conducted for segments MT41I006_030 and MT41I006_020. The goals of the modeling runs were threefold: 1) to create reasonably accurate temperature models for segments MT41I006_030 and MT41I006_020; 2) to evaluate the potential effectiveness of various restoration measures in reducing instream water temperatures in these segments; and 3) to compare modeled temperatures for Prickly Pear Creek to naturally occurring temperatures so that results could be evaluated using B-1 temperature standards. See Part 5 for the model outputs and sensitivity analyses.

The calibration models for segments MT41I006_030 and MT41I006_020 were run using the input data discussed in Section 1. For segment MT41I006_020, two calibration models were run: 1) from the beginning of the segment to Sierra Road, and 2) for the entire segment.
Restoration measures of riparian vegetation enhancement, cooler inflow temperatures, and flow augmentation were then modeled in order to assess the effectiveness of each measure alone as well as in combination. For segment MT41I006_030, vegetation density was increased from 20 to 60% on the west and from 60 to 75% on the east. Vegetation density for segment MT41I006_020 was increased from 60 to 75% on the west and from 20 to 60% on the east. Inflow temperature for segment MT41I006_030 was modeled at 5 degrees less than the current temperature. In another scenario for segment MT41I006_030, the inflow was augmented to 30 cfs. This value represents the upper inflection point modeled by the Montana Department of Fish, Wildlife and Parks as needed to support a viable salmonid fishery in the lower reaches of Prickly Pear Creek (MFWP, 1989). In order to calculate inflow temperature at the beginning of segment MT41I006_020 resulting from augmented flows in segment MT41I006_030, the equation for the temperature of mixing streams was used (Bartholow, 2002). First, the temperature of inflow from the Helena wastewater treatment plant (WWTP, 2.5 cfs at X° F) was back calculated from the calibration model with the diel data from the lower site on MT41I006_030 (1.5 cfs at 59.4° F). The result of the back calculation was 62° F. The inflow temperature value (62° F) and flow contribution (2.5 cfs) for the WWTP were combined with the model outputs from segment MT41I006_030 to generate model input values for segment MT41I006_020.

Naturally occurring temperature for segment MT41I006_030 was believed to be the restoration model with an inflow of 30cfs at 62.5° F with enhanced riparian vegetation density along the segment. For segment MT41I006_020, naturally occurring temperature was believed to be the restoration model that used the model output from the natural temperature model for segment MT41I006_030 and augmented riparian vegetation density along the segment.

H.3.0 SSTEMP Modeling Results

SSTEMP modeling results were compared to diel temperature survey data collected on August 7th, 2003. For segment MT41I006_030, model outputs were compared to diel temperature data collected near the beginning of the segment (just below Wylie Drive, Table H-5). For segment MT41I006_020, model outputs were compared to diel temperature data collected at Sierra Road (Table H-5). Bartholow states that "the theoretical basis for the model is strongest for the mean daily temperature" (p.13, 2002). Therefore, mean temperature values were given the most consideration.

Table H-5. Diel temperature collected on August 7th, 2003 for segments MT41I006_030 and MT41I006_020.

Statistics	MT41I006_030	MT41I006_020
Mean	69.4 ° F	65.0 ° F
Median	68.4 ° F	63.9 ° F
Standard Deviation	5.6 ° F	5.5 ° F
Minimum	62.8 ° F	59.0 ° F
Maximum	78.1 ° F	73.8 ° F

The calibration model for segment MT41I006_030 produced mean temperature results within 1% of the measured value (Table H-6). The modeled value of 68.7 ° F is 0.7 ° F less than the measured value. This is a reasonable outcome given that the measured temperature was recorded at the beginning of the segment before any inflow from groundwater was gained.

The calibration models for segment MT41I006_020 produced similar results (Table H-6). The first model for segment MT41I006_020 was run to the point of measured data collection, where inflow and inflow temperature were adjusted to fit the observed mean temperature. Again, the modeled mean value of 64.1 ° F for the entire segment is less than the measured value recorded near the middle of the segment. The difference is greater in segment MT41I006_020 than in segment MT41I006_030 due to the larger amount of water gained in this segment.

Table H-6. Results of the calibration models for segments MT41I006_030 and MT41I006_020.

Segment	Parameter	Value	Difference from Measured Value	% Different
MT41I006_030	Mean	68.7° F	-0.7° F	1
	Maximum	78.3° F	+0.2° F	0
	Minimum	59.1° F	-3.7° F	6
MT41I006_020 to Sierra Road	Mean	65.0° F	+0.0° F	0
	Maximum	74.1° F	+0.4° F	1
	Minimum	55.9° F	-3.1° F	5
MT41I006_020 entire segment	Mean	64.1° F	-0.9° F	1
	Maximum	72.0° F	-1.8° F	2
	Minimum	56.2° F	-2.8° F	5

For current conditions (low flow), increasing riparian vegetation density from 20 to 60% on the west and from 60 to 75% on the east for segment MT41I006_030 will result in the largest mean water temperature reduction. Should flows be augmented to 30 cfs in this segment, the inflows will need to be cooler to see much of a reduction in mean water temperature. Cooler inflows at 30 cfs with augmented vegetative density would have the greatest improvement on mean temperature in segment MT41I006_020 (Table H-7).

Similar results were modeled for segment MT41I006_020. Under current conditions, improving vegetative density from 60 to 75% on the west and from 20 to 60% on the east could reduce mean water temperature by about 2.5° F. Should flows be augmented in segment MT41I006_030, the result will be to increase heating in segment MT41I006_020, unless cooler inflows and increased vegetation density are achieved in segment MT41I006_030 (Table 7).

Table H-7. Results of the restoration models for segments MT41I006_030 and MT41I006_020.

Segment	Restoration Measure	Parameter	Value	Difference from Measured Value	% Different
MT41I006_030	1. Increase vegetation density	Mean	66.0° F	-3.4° F	5
MT41I006_030	2. Cool inflow by 5 °F	Mean	68.7° F	-0.7° F	1
MT41I006_030	3. Increase vegetation density and cool inflow	Mean	66.0° F	-3.4° F	5
MT41I006_030	4. Increase inflow to 30 cfs	Mean	68.4° F	-1.0° F	1
MT41I006_030	5. Increase vegetation density and inflow to 30 cfs	Mean	67.5° F	-2.0° F	3
MT41I006_030	6. Increase inflow to 30 cfs and cool by 5 °F	Mean	65.2° F	-4.2° F	6
MT41I006_030	7. Increase vegetation density, inflow to 30 cfs, and cool by 5 °F	Mean	64.3° F	-5.1° F	7
MT41I006_020	1. Increase vegetation density	Mean	62.5° F	-2.5° F	4
MT41I006_020	2. Inflow from restoration 4 in segment MT41I006_030	Mean	66.3° F	+1.3° F	2
MT41I006_020	3. Increase vegetation density with inflow from restoration 4 in segment MT41I006_030	Mean	65.3° F	+0.3° F	0
MT41I006_020	4. Inflow from restoration 6 in segment MT41I006_030	Mean	65.2° F	+0.2° F	0
MT41I006_020	5. Increase vegetation density with inflow from restoration 6 in segment MT41I006_030	Mean	64.2° F	-0.8° F	1
MT41I006_020	6. Inflow from restoration 7 in segment MT41I006_030	Mean	64.9° F	-0.1° F	0

Segment	Restoration Measure	Parameter	Value	Difference from Measured Value	% Different
MT411006_020	7. Increase vegetation density with inflow from restoration 7 in segment MT411006_030	Mean	63.9° F	-1.1° F	2
MT411006_020 to Sierra Road	7. Increase vegetation density with inflow from restoration 7 in segment MT411006_030	Mean	64.5° F	-0.5° F	1

In comparison to natural temperatures, under current modeled conditions (calibration model) segment MT411006_030 is in violation of B-1 temperature standards (the goal for this I-class stream). Montana Administrative Rules for B-1 standards state that "the maximum allowable increase over naturally occurring temperature (if the naturally occurring temperature is less than 67° F) is 1° F (ARM 17.30.629). SSTEMP modeled segment MT411006_030 with 4.4 degrees in excess of natural temperature (Table H-8). Accounting for uncertainty of the models for segment MT411006_030, the stream is at best 2.6° F or at worst 6.2° F above natural temperatures. Segment MT411006_020 is probably in violation of B-1 temperature standards as well (Table H-8). Although the differences from natural values for both calibrations models are less than one degree, once model uncertainty is accounted for the possibility of violating the state's standard must be considered.

Table H-8. Current conditions versus natural conditions for segments MT411006_030 and MT411006_020.

Segment	Current Temperature (Mean)	Calibration Model Uncertainty (Mean)	Natural Temperature (Mean)	Natural Model Uncertainty (Mean)	Difference from Natural Value (Best and Worst Case)
MT411006_030	68.7° F	± 1.0° F	64.3° F	± 0.8° F	**+4.4**° F (2.6 to 6.3)
MT411006_020 to Sierra Road	65.0° F	± 1.4° F	64.5° F	± 0.9° F	-0.5° F (-1.8 to **2.8**)
MT411006_020 (whole segment)	64.1° F	± 1.8° F	63.9° F	± 1.2° F	-0.2° F (-2.8 to **3.2**)

H.5.0 Conclusions

Limited in-stream field data were available to calibrate the SSTEMP models. The calibration data collected in 2003 represented extreme drought conditions and unusually hot weather. This is especially important given the fact that air temperature is a very significant variable for the SSTEMP model. Nonetheless, the calibration models appeared to give reasonable estimates of mean temperature for both of the suspected thermally impaired segments of Prickly Pear Creek.

The goals of modeling with SSTEMP were to determine the relative benefits of restoration measures, such as augmenting flows, and to determine if B-1 temperature standards are violated within the suspected thermally impaired segments. The modeled average temperatures for segments MT41I006_020 and MT41I006_030 were above the natural temperatures, and thus violate the state standard set for B-1 class streams naturally below 67° F. Of the significant 'controllable' variables revealed in the sensitivity analysis, increasing riparian vegetation density appeared to have the greatest potential impact on reducing mean instream water temperatures. Other significant 'controllable' variables in order of importance were inflow temperature, streamflow, and channel morphology variables. When flows were augmented the input flow temperatures became even more important than air temperatures. Should the ultimate goal of restoring coldwater fisheries and associated aquatic life in lower Prickly Pear Creek be realized, it would appear that restoration measures will need to extend upstream of the listed segments in order to reduce inflow temperatures below those recorded in segment MT41I006_040 in 2003.

H.6.0 References

ARM. 2002. *Surface Water Quality Standards and Procedures.* Administrative Rules of Montana 17.30.601-646, Helena, Montana.

Bartholow, J. 2002. Stream Segment Temperature Model (SSTEMP), Version 2.0, User's Manual. United States Geological Survey, Fort Collins Science Center Online, Fort Collins, CO http://www.fort.usgs.gov/products/training/if312.asp.

Montana Department of Fish Wildlife and Parks. 1989. Application for Reservations of Water in the Missouri River Basin Above Fort Peck Dam, Volume 3, Reservation Requests for Waters Between Canyon Ferry Dam and Fort Peck Dam. MT FWP, Helena, MT.

USGS. 2003. National Water Information System [Online]. U. S. Geological Survey. Available at http://waterdata.usgs.gov/nwis/.

Weather Underground. 2004. Detailed History and Climate Data for Helena Regional Airport. Weather Underground website at http://www.wunderground.com. August 7th, 2003.

H.7.0 SSTEMP Model Output

Prickly Pear Segment MT41I006_030

Scenario 1. Current conditions with no diversions in segment.

```
"SSTEMP (2.0.8)"
"English",      "Segment Inflow (cfs)",          "1.000"
"English",      "Inflow Temperature (°F)",       "67.500"
"English",      "Segment Outflow (cfs)",         "2.500"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.600"
"English",      "Segment Length (mi)",           "4.420"
"English",      "Upstream Elevation (ft)",       "3840.00"
"English",      "Downstream Elevation (ft)",     "3705.00"
"English",      "Width's A Term (s/ft²)",        "14.400"
"English",      "  B Term where W = A*Q**B",     "0.110"
"English",      "Manning's n",                   "0.032"
"English",      "Air Temperature (°F)",          "78.440"
"English",      "Relative Humidity (%)",         "32.800"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.940"
"English",      "Total Shade (%)",               "29.473"
"English",      "Segment Azimuth (degrees)",     "-45.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "10.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "20.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "15.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "60.000"
"English",      " Maximum Air Temp (°F)",        "83.422"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
      "Predicted Mean (°F) = 68.68"
      "Estimated Maximum (°F) = 78.29"
      "Approximate Minimum (°F) = 59.08"
      "Mean Equilibrium (°F) = 70.77"
      "Maximum Equilibrium (°F) = 79.15"
      "Minimum Equilibrium (°F) = 62.39"
```

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 68.68°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	-0.13	+0.13	*
Inflow Temperature (°F)	-0.02	+0.02	
Segment Outflow (cfs)	+0.27	-0.29	**
Accretion Temp. (°F)	-0.73	+0.73	*****
Width's A Term (s/ft²)	-0.23	+0.27	**
B Term where W = A*Q**B	-0.02	+0.02	
Manning's n	+0.00	+0.00	
Air Temperature (°F)	-4.53	+4.31	**********
Relative Humidity (%)	-0.72	+0.73	*****
Wind Speed (mph)	+0.31	-0.34	**
Ground Temperature (°F)	-0.23	+0.23	**
Thermal gradient (j/m²/s/C)	+0.06	-0.06	
Possible Sun (%)	-0.31	+0.44	***
Dust Coefficient	+0.03	-0.03	
Ground Reflectivity (%)	-0.03	+0.03	
Segment Azimuth (degrees)	-0.17	+0.17	*
West Side:			
Topographic Altitude (degrees)	+0.09	-0.07	*
Vegetation Height (ft)	+0.03	-0.04	
Vegetation Crown (ft)	+0.02	-0.02	
Vegetation Offset (ft)	-0.02	+0.02	
Vegetation Density (%)	+0.11	-0.11	*
East Side:			
Topographic Altitude (degrees)	+0.01	-0.01	
Vegetation Height (ft)	+0.02	-0.02	
Vegetation Crown (ft)	+0.03	-0.03	
Vegetation Offset (ft)	-0.02	+0.02	
Vegetation Density (%)	+0.15	-0.15	*

Sensitivity for maximum temperature values (10% varaition) SSTEMP (2.0.8)
Original maximum temperature = 78.29°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	-0.06	+0.06	
Inflow Temperature (°F)	-0.01	+0.01	
Segment Outflow (cfs)	+0.16	-0.16	*
Accretion Temp. (°F)	-0.29	+0.29	**
Width's A Term (s/ft²)	-0.23	+0.27	**
B Term where W = A*Q**B	-0.01	+0.02	
Manning's n	+0.05	-0.06	
Air Temperature (°F)	-3.98	+3.81	**********
Relative Humidity (%)	-0.58	+0.59	****
Wind Speed (mph)	+0.58	-0.62	*****
Ground Temperature (°F)	-0.21	+0.21	**
Thermal gradient (j/m²/s/C)	+0.09	-0.09	*
Possible Sun (%)	-0.63	+0.86	******
Dust Coefficient	+0.04	-0.04	
Ground Reflectivity (%)	-0.04	+0.04	

Segment Azimuth (degrees)	-0.30	+0.30 **
West Side:		
Topographic Altitude (degrees)	+0.17	-0.13 *
Vegetation Height (ft)	+0.05	-0.07 *
Vegetation Crown (ft)	+0.03	-0.03
Vegetation Offset (ft)	-0.03	+0.03
Vegetation Density (%)	+0.20	-0.20 **
East Side:		
Topographic Altitude (degrees)	+0.03	-0.02
Vegetation Height (ft)	+0.04	-0.04
Vegetation Crown (ft)	+0.06	-0.06
Vegetation Offset (ft)	-0.04	+0.04
Vegetation Density (%)	+0.27	-0.27 **

Scenario 2. Same as Scenario 1 but increase vegetation density

```
"SSTEMP (2.0.8)  "
"English",      "Segment Inflow (cfs)",          "1.000"
"English",      "Inflow Temperature (°F)",       "67.500"
"English",      "Segment Outflow (cfs)",         "2.500"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.600"
"English",      "Segment Length (mi)",           "4.420"
"English",      "Upstream Elevation (ft)",       "3840.00"
"English",      "Downstream Elevation (ft)",     "3705.00"
"English",      "Width's A Term (s/ft²)",        "14.400"
"English",      "  B Term where W = A*Q**B",     "0.110"
"English",      "Manning's n",                   "0.032"
"English",      "Air Temperature (°F)",          "78.440"
"English",      "Relative Humidity (%)",         "32.800"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.940"
"English",      "Total Shade (%)",               "53.978"
"English",      "Segment Azimuth (degrees)",     "-45.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "10.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "60.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "15.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "75.000"
"English",      " Maximum Air Temp (°F)",        "83.422"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
      "Predicted Mean (°F) = 66.00"
      "Estimated Maximum (°F) = 73.40"
      "Approximate Minimum (°F) = 58.60"
      "Mean Equilibrium (°F) = 67.78"
      "Maximum Equilibrium (°F) = 74.39"
      "Minimum Equilibrium (°F) = 61.17"

Sensitivity for mean temperature values (10% variation)    SSTEMP (2.0.8)
Original mean temperature = 66.00°F
                        Temperature change (°F)
                           if variable is:
Variable                   Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
```

Segment Inflow (cfs)	-0.11	+0.11	*
Inflow Temperature (°F)	-0.02	+0.02	
Segment Outflow (cfs)	+0.23	-0.24	**
Accretion Temp. (°F)	-0.77	+0.77	*****
Width's A Term (s/ft²)	-0.29	+0.32	**
B Term where W = A*Q**B	-0.02	+0.02	
Manning's n	+0.00	+0.00	
Air Temperature (°F)	-4.73	+4.50	**********
Relative Humidity (%)	-0.73	+0.74	*****
Wind Speed (mph)	+0.23	-0.25	**
Ground Temperature (°F)	-0.24	+0.24	**
Thermal gradient (j/m²/s/C)	+0.05	-0.05	
Possible Sun (%)	-0.21	+0.30	**
Dust Coefficient	+0.02	-0.02	
Ground Reflectivity (%)	-0.02	+0.02	
Segment Azimuth (degrees)	-0.09	+0.09	*
West Side:			
Topographic Altitude (degrees)	+0.05	-0.04	
Vegetation Height (ft)	+0.09	-0.12	*
Vegetation Crown (ft)	+0.06	-0.06	
Vegetation Offset (ft)	-0.06	+0.06	
Vegetation Density (%)	+0.35	-0.35	**
East Side:			
Topographic Altitude (degrees)	+0.01	-0.01	
Vegetation Height (ft)	+0.03	-0.03	
Vegetation Crown (ft)	+0.04	-0.04	
Vegetation Offset (ft)	-0.03	+0.03	
Vegetation Density (%)	+0.20	-0.20	*

Sensitivity for maximum temperature values (10% varaition) SSTEMP (2.0.8)
Original maximum temperature = 73.40°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	-0.07	+0.07	
Inflow Temperature (°F)	-0.01	+0.01	
Segment Outflow (cfs)	+0.15	-0.15	*
Accretion Temp. (°F)	-0.40	+0.40	***
Width's A Term (s/ft²)	-0.39	+0.43	***
B Term where W = A*Q**B	-0.02	+0.02	
Manning's n	+0.05	-0.05	
Air Temperature (°F)	-4.35	+4.17	**********
Relative Humidity (%)	-0.62	+0.63	****
Wind Speed (mph)	+0.42	-0.45	***
Ground Temperature (°F)	-0.23	+0.23	**
Thermal gradient (j/m²/s/C)	+0.08	-0.08	*
Possible Sun (%)	-0.49	+0.64	****
Dust Coefficient	+0.03	-0.03	
Ground Reflectivity (%)	-0.03	+0.03	
Segment Azimuth (degrees)	-0.17	+0.17	*
West Side:			
Topographic Altitude (degrees)	+0.10	-0.08	*
Vegetation Height (ft)	+0.18	-0.23	**
Vegetation Crown (ft)	+0.12	-0.11	*
Vegetation Offset (ft)	-0.11	+0.12	*

Vegetation Density (%)	+0.66	-0.65	*****
East Side:			
Topographic Altitude (degrees)	+0.02	-0.02	
Vegetation Height (ft)	+0.06	-0.06	
Vegetation Crown (ft)	+0.08	-0.08	*
Vegetation Offset (ft)	-0.05	+0.05	
Vegetation Density (%)	+0.38	-0.37	***

Scenario 3. Same as Scenario 1 but cool inflow by 5° F

"SSTEMP (2.0.8) "
"English", "Segment Inflow (cfs)", "1.000"
"English", "Inflow Temperature (°F)", "62.500"
"English", "Segment Outflow (cfs)", "2.500"
"English", "Accretion Temp. (°F)", "55.000"
"English", "Latitude (degrees)", "46.600"
"English", "Segment Length (mi)", "4.420"
"English", "Upstream Elevation (ft)", "3840.00"
"English", "Downstream Elevation (ft)", "3705.00"
"English", "Width's A Term (s/ft²)", "14.400"
"English", " B Term where W = A*Q**B", "0.110"
"English", "Manning's n", "0.032"
"English", "Air Temperature (°F)", "78.440"
"English", "Relative Humidity (%)", "32.800"
"English", "Wind Speed (mph)", "7.100"
"English", "Ground Temperature (°F)", "55.000"
"English", "Thermal gradient (j/m²/s/C)", "1.650"
"English", "Possible Sun (%)", "90.000"
"English", "Dust Coefficient", "5.000"
"English", "Ground Reflectivity (%)", "25.000"
"English", "Solar Radiation (Langleys/d)", "630.940"
"English", "Total Shade (%)", "29.473"
"English", "Segment Azimuth (degrees)", "-45.000"
"West Side Variables"
"English", "Topographic Altitude (degrees)", "25.000"
"English", "Vegetation Height (ft)", "25.000"
"English", "Vegetation Crown (ft)", "10.000"
"English", "Vegetation Offset (ft)", "5.000"
"English", "Vegetation Density (%)", "20.000"
"East Side Variables"
"English", "Segment Azimuth (degrees)", "15.000"
"English", "Topographic Altitude (degrees)", "35.000"
"English", "Vegetation Height (ft)", "15.000"
"English", "Vegetation Crown (ft)", "5.000"
"English", "Vegetation Offset (ft)", "60.000"
"English", " Maximum Air Temp (°F)", "83.422"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
"Predicted Mean (°F) = 68.67"
"Estimated Maximum (°F) = 78.28"
"Approximate Minimum (°F) = 59.06"
"Mean Equilibrium (°F) = 70.77"
"Maximum Equilibrium (°F) = 79.15"
"Minimum Equilibrium (°F) = 62.39"

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 68.67°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity

Segment Inflow (cfs)	-0.13	+0.13	*
Inflow Temperature (°F)	-0.02	+0.02	
Segment Outflow (cfs)	+0.27	-0.29	**
Accretion Temp. (°F)	-0.73	+0.73	*****
Width's A Term (s/ft²)	-0.23	+0.27	**
B Term where W = A*Q**B	-0.02	+0.02	
Manning's n	+0.00	+0.00	
Air Temperature (°F)	-4.53	+4.31	**********
Relative Humidity (%)	-0.72	+0.73	*****
Wind Speed (mph)	+0.31	-0.34	**
Ground Temperature (°F)	-0.23	+0.23	**
Thermal gradient (j/m²/s/C)	+0.06	-0.06	
Possible Sun (%)	-0.31	+0.44	***
Dust Coefficient	+0.03	-0.03	
Ground Reflectivity (%)	-0.03	+0.03	
Segment Azimuth (degrees)	-0.17	+0.17	*
West Side:			
Topographic Altitude (degrees)	+0.09	-0.07	*
Vegetation Height (ft)	+0.03	-0.04	
Vegetation Crown (ft)	+0.02	-0.02	
Vegetation Offset (ft)	-0.02	+0.02	
Vegetation Density (%)	+0.11	-0.11	*
East Side:			
Topographic Altitude (degrees)	+0.01	-0.01	
Vegetation Height (ft)	+0.02	-0.02	
Vegetation Crown (ft)	+0.03	-0.03	
Vegetation Offset (ft)	-0.02	+0.02	
Vegetation Density (%)	+0.15	-0.15	*

Sensitivity for maximum temperature values (10% varaition) SSTEMP (2.0.8)
Original maximum temperature = 78.28°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	-0.06	+0.06	
Inflow Temperature (°F)	-0.01	+0.01	
Segment Outflow (cfs)	+0.16	-0.16	*
Accretion Temp. (°F)	-0.29	+0.29	**
Width's A Term (s/ft²)	-0.23	+0.27	**
B Term where W = A*Q**B	-0.01	+0.02	
Manning's n	+0.05	-0.06	
Air Temperature (°F)	-3.98	+3.81	**********
Relative Humidity (%)	-0.58	+0.59	****
Wind Speed (mph)	+0.58	-0.62	*****
Ground Temperature (°F)	-0.21	+0.21	**
Thermal gradient (j/m²/s/C)	+0.09	-0.09	*
Possible Sun (%)	-0.63	+0.86	******
Dust Coefficient	+0.04	-0.04	
Ground Reflectivity (%)	-0.04	+0.04	
Segment Azimuth (degrees)	-0.30	+0.30	**
West Side:			
Topographic Altitude (degrees)	+0.17	-0.13	*
Vegetation Height (ft)	+0.05	-0.07	*
Vegetation Crown (ft)	+0.04	-0.03	
Vegetation Offset (ft)	-0.03	+0.04	

Vegetation Density (%)	+0.20	-0.20 **
East Side:		
Topographic Altitude (degrees)	+0.03	-0.02
Vegetation Height (ft)	+0.04	-0.04
Vegetation Crown (ft)	+0.06	-0.06
Vegetation Offset (ft)	-0.04	+0.04
Vegetation Density (%)	+0.27	-0.27 **

Scenario 4. Same as Scenario 1 but increase vegetation density and cool inflow by 5° F

```
"SSTEMP (2.0.8) "
"English",      "Segment Inflow (cfs)",          "1.000"
"English",      "Inflow Temperature (°F)",       "62.500"
"English",      "Segment Outflow (cfs)",         "2.500"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.600"
"English",      "Segment Length (mi)",           "4.420"
"English",      "Upstream Elevation (ft)",       "3840.00"
"English",      "Downstream Elevation (ft)",     "3705.00"
"English",      "Width's A Term (s/ft²)",        "14.400"
"English",      "  B Term where W = A*Q**B",     "0.110"
"English",      "Manning's n",                   "0.032"
"English",      "Air Temperature (°F)",          "78.440"
"English",      "Relative Humidity (%)",         "32.800"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.940"
"English",      "Total Shade (%)",               "53.978"
"English",      "Segment Azimuth (degrees)",     "-45.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "10.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "60.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "15.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "75.000"
"English",      " Maximum Air Temp (°F)",        "83.422"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
      "Predicted Mean (°F) = 65.99"
      "Estimated Maximum (°F) = 73.40"
      "Approximate Minimum (°F) = 58.58"
      "Mean Equilibrium (°F) = 67.78"
      "Maximum Equilibrium (°F) = 74.39"
      "Minimum Equilibrium (°F) = 61.17"

Sensitivity for mean temperature values (10% variation)    SSTEMP (2.0.8)
Original mean temperature = 65.99°F
                    Temperature change (°F)
                       if variable is:
Variable                Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
```

Segment Inflow (cfs)	-0.11	+0.11	*
Inflow Temperature (°F)	-0.02	+0.02	
Segment Outflow (cfs)	+0.23	-0.24	**
Accretion Temp. (°F)	-0.77	+0.77	*****
Width's A Term (s/ft²)	-0.29	+0.32	**
B Term where W = A*Q**B	-0.02	+0.02	
Manning's n	+0.00	+0.00	
Air Temperature (°F)	-4.73	+4.50	**********
Relative Humidity (%)	-0.73	+0.74	*****
Wind Speed (mph)	+0.23	-0.25	**
Ground Temperature (°F)	-0.24	+0.25	**
Thermal gradient (j/m²/s/C)	+0.05	-0.05	
Possible Sun (%)	-0.21	+0.30	**
Dust Coefficient	+0.02	-0.02	
Ground Reflectivity (%)	-0.02	+0.02	
Segment Azimuth (degrees)	-0.09	+0.09	*
West Side:			
Topographic Altitude (degrees)	+0.05	-0.04	
Vegetation Height (ft)	+0.09	-0.12	*
Vegetation Crown (ft)	+0.06	-0.06	
Vegetation Offset (ft)	-0.06	+0.06	
Vegetation Density (%)	+0.35	-0.35	**
East Side:			
Topographic Altitude (degrees)	+0.01	-0.01	
Vegetation Height (ft)	+0.03	-0.03	
Vegetation Crown (ft)	+0.04	-0.04	
Vegetation Offset (ft)	-0.03	+0.03	
Vegetation Density (%)	+0.20	-0.20	*

Sensitivity for maximum temperature values (10% varaition) SSTEMP (2.0.8)
Original maximum temperature = 73.40°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	-0.07	+0.07	
Inflow Temperature (°F)	-0.01	+0.01	
Segment Outflow (cfs)	+0.16	-0.15	*
Accretion Temp. (°F)	-0.40	+0.40	***
Width's A Term (s/ft²)	-0.39	+0.43	***
B Term where W = A*Q**B	-0.02	+0.02	
Manning's n	+0.05	-0.05	
Air Temperature (°F)	-4.35	+4.17	**********
Relative Humidity (%)	-0.62	+0.63	****
Wind Speed (mph)	+0.42	-0.45	***
Ground Temperature (°F)	-0.23	+0.23	**
Thermal gradient (j/m²/s/C)	+0.08	-0.08	*
Possible Sun (%)	-0.49	+0.64	****
Dust Coefficient	+0.03	-0.03	
Ground Reflectivity (%)	-0.03	+0.03	
Segment Azimuth (degrees)	-0.17	+0.17	*
West Side:			
Topographic Altitude (degrees)	+0.10	-0.08	*
Vegetation Height (ft)	+0.18	-0.23	**
Vegetation Crown (ft)	+0.12	-0.11	*
Vegetation Offset (ft)	-0.11	+0.12	*

Vegetation Density (%)	+0.66	-0.65	*****
East Side:			
Topographic Altitude (degrees)	+0.02	-0.02	
Vegetation Height (ft)	+0.06	-0.06	
Vegetation Crown (ft)	+0.08	-0.08	*
Vegetation Offset (ft)	-0.05	+0.05	
Vegetation Density (%)	+0.38	-0.37	***

Scenario 5. Same as Scenario 1 but begin with 30 cfs

"SSTEMP (2.0.8)"
"English", "Segment Inflow (cfs)", "30.000"
"English", "Inflow Temperature (°F)", "67.500"
"English", "Segment Outflow (cfs)", "31.500"
"English", "Accretion Temp. (°F)", "55.000"
"English", "Latitude (degrees)", "46.600"
"English", "Segment Length (mi)", "4.420"
"English", "Upstream Elevation (ft)", "3840.00"
"English", "Downstream Elevation (ft)", "3705.00"
"English", "Width's A Term (s/ft²)", "14.400"
"English", " B Term where W = A*Q**B", "0.110"
"English", "Manning's n", "0.032"
"English", "Air Temperature (°F)", "78.440"
"English", "Relative Humidity (%)", "32.800"
"English", "Wind Speed (mph)", "7.100"
"English", "Ground Temperature (°F)", "55.000"
"English", "Thermal gradient (j/m²/s/C)", "1.650"
"English", "Possible Sun (%)", "90.000"
"English", "Dust Coefficient", "5.000"
"English", "Ground Reflectivity (%)", "25.000"
"English", "Solar Radiation (Langleys/d)", "630.940"
"English", "Total Shade (%)", "27.022"
"English", "Segment Azimuth (degrees)", "-45.000"
"West Side Variables"
"English", "Topographic Altitude (degrees)", "25.000"
"English", "Vegetation Height (ft)", "25.000"
"English", "Vegetation Crown (ft)", "10.000"
"English", "Vegetation Offset (ft)", "5.000"
"English", "Vegetation Density (%)", "20.000"
"East Side Variables"
"English", "Segment Azimuth (degrees)", "15.000"
"English", "Topographic Altitude (degrees)", "35.000"
"English", "Vegetation Height (ft)", "15.000"
"English", "Vegetation Crown (ft)", "5.000"
"English", "Vegetation Offset (ft)", "60.000"
"English", " Maximum Air Temp (°F)", "83.422"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
"Predicted Mean (°F) = 68.38"
"Estimated Maximum (°F) = 75.58"
"Approximate Minimum (°F) = 61.19"
"Mean Equilibrium (°F) = 71.43"
"Maximum Equilibrium (°F) = 79.90"
"Minimum Equilibrium (°F) = 62.95"

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 68.38°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity

```
Segment Inflow (cfs)          -0.46    +0.97 *******
Inflow Temperature (°F)        -4.08    +4.30 ******************************
Segment Outflow (cfs)          +0.98    -0.54 *******
Accretion Temp. (°F)          -0.20    +0.21 *
Width's A Term (s/ft²)        -0.14    +0.14 *
  B Term where W = A*Q**B       -0.05    +0.05
Manning's n                 +0.00    +0.00
Air Temperature (°F)          -1.89    +1.66 *************
Relative Humidity (%)          -0.29    +0.29 **
Wind Speed (mph)              +0.12    -0.12 *
Ground Temperature (°F)        -0.09    +0.09 *
Thermal gradient (j/m²/s/C)    +0.02    -0.02
Possible Sun (%)             -0.13    +0.18 *
Dust Coefficient             +0.01    -0.01
Ground Reflectivity (%)        -0.01    +0.01
Segment Azimuth (degrees)      -0.07    +0.07
West Side:
Topographic Altitude (degrees)  +0.04    -0.03
Vegetation Height (ft)        +0.02    -0.02
Vegetation Crown (ft)          +0.01    -0.01
Vegetation Offset (ft)        -0.01    +0.01
Vegetation Density (%)         +0.04    -0.04
East Side:
Topographic Altitude (degrees)  +0.01    -0.01
Vegetation Height (ft)        +0.01    -0.01
Vegetation Crown (ft)          +0.01    -0.01
Vegetation Offset (ft)        -0.01    +0.01
Vegetation Density (%)         +0.06    -0.06

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 75.58°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased  Relative Sensitivity
-----------------------------------------------------------------------------
Segment Inflow (cfs)          -0.37    +0.78 *******
Inflow Temperature (°F)        -3.17    +3.34 ******************************
Segment Outflow (cfs)          +0.95    -0.61 *********
Accretion Temp. (°F)          -0.16    +0.16 *
Width's A Term (s/ft²)        -0.37    +0.41 ****
  B Term where W = A*Q**B       -0.15    +0.15 *
Manning's n                 +0.19    -0.20 **
Air Temperature (°F)          -2.19    +1.97 ********************
Relative Humidity (%)          -0.29    +0.30 ***
Wind Speed (mph)              +0.27    -0.28 **
Ground Temperature (°F)        -0.11    +0.11 *
Thermal gradient (j/m²/s/C)    +0.05    -0.05
Possible Sun (%)             -0.46    +0.60 *****
Dust Coefficient             +0.03    -0.03
Ground Reflectivity (%)        -0.03    +0.03
Segment Azimuth (degrees)      -0.21    +0.20 **
West Side:
Topographic Altitude (degrees)  +0.11    -0.08 *
Vegetation Height (ft)        +0.05    -0.06 *
Vegetation Crown (ft)          +0.03    -0.03
Vegetation Offset (ft)        -0.03    +0.03
```

Vegetation Density (%)	+0.12	-0.12 *
East Side:		
Topographic Altitude (degrees)	+0.02	-0.02
Vegetation Height (ft)	+0.04	-0.04
Vegetation Crown (ft)	+0.04	-0.04
Vegetation Offset (ft)	-0.02	+0.02
Vegetation Density (%)	+0.17	-0.17 **

Scenario 6. Same as Scenario 5 but increase vegetation density

```
"SSTEMP (2.0.8)"
"English",      "Segment Inflow (cfs)",          "30.000"
"English",      "Inflow Temperature (°F)",       "67.500"
"English",      "Segment Outflow (cfs)",         "31.500"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.600"
"English",      "Segment Length (mi)",           "4.420"
"English",      "Upstream Elevation (ft)",       "3840.00"
"English",      "Downstream Elevation (ft)",     "3705.00"
"English",      "Width's A Term (s/ft²)",        "14.400"
"English",      "  B Term where W = A*Q**B",     "0.110"
"English",      "Manning's n",                   "0.032"
"English",      "Air Temperature (°F)",          "78.440"
"English",      "Relative Humidity (%)",         "32.800"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.940"
"English",      "Total Shade (%)",               "48.807"
"English",      "Segment Azimuth (degrees)",     "-45.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "10.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "60.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "15.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "75.000"
"English",      " Maximum Air Temp (°F)",        "83.422"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
      "Predicted Mean (°F) = 67.45"
      "Estimated Maximum (°F) = 72.80"
      "Approximate Minimum (°F) = 62.11"
      "Mean Equilibrium (°F) = 68.81"
      "Maximum Equilibrium (°F) = 75.77"
      "Minimum Equilibrium (°F) = 61.85"

Sensitivity for mean temperature values (10% variation)    SSTEMP (2.0.8)
Original mean temperature = 67.45°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
```

```
Segment Inflow (cfs)            -0.49    +1.00 *******
Inflow Temperature (°F)          -4.10    +4.32 ******************************
Segment Outflow (cfs)           +0.94    -0.51 *******
Accretion Temp. (°F)            -0.21    +0.22 *
Width's A Term (s/ft²)          -0.11    +0.11 *
  B Term where W = A*Q**B        -0.04    +0.04
Manning's n                   +0.00    +0.00
Air Temperature (°F)            -1.88    +1.65 *************
Relative Humidity (%)           -0.28    +0.28 **
Wind Speed (mph)               +0.11    -0.11 *
Ground Temperature (°F)          -0.09    +0.09 *
Thermal gradient (j/m²/s/C)      +0.02    -0.02
Possible Sun (%)              -0.09    +0.13 *
Dust Coefficient              +0.01    -0.01
Ground Reflectivity (%)          -0.01    +0.01
Segment Azimuth (degrees)        -0.04    +0.04
West Side:
Topographic Altitude (degrees)   +0.02    -0.01
Vegetation Height (ft)          +0.05    -0.06
Vegetation Crown (ft)           +0.03    -0.03
Vegetation Offset (ft)          -0.03    +0.03
Vegetation Density (%)          +0.12    -0.12 *
East Side:
Topographic Altitude (degrees)   +0.00     0.00
Vegetation Height (ft)          +0.02    -0.02
Vegetation Crown (ft)           +0.02    -0.02
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)          +0.07    -0.07

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 72.80°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-------------------------------------------------------------------------------
Segment Inflow (cfs)            -0.43    +0.85 *******
Inflow Temperature (°F)          -3.41    +3.59 ******************************
Segment Outflow (cfs)           +0.93    -0.56 ********
Accretion Temp. (°F)            -0.18    +0.18 *
Width's A Term (s/ft²)          -0.40    +0.42 ***
  B Term where W = A*Q**B        -0.16    +0.16 *
Manning's n                   +0.14    -0.16 *
Air Temperature (°F)            -2.16    +1.93 ******************
Relative Humidity (%)           -0.29    +0.29 **
Wind Speed (mph)               +0.20    -0.21 **
Ground Temperature (°F)          -0.11    +0.11 *
Thermal gradient (j/m²/s/C)      +0.04    -0.04
Possible Sun (%)              -0.33    +0.43 ****
Dust Coefficient              +0.02    -0.02
Ground Reflectivity (%)          -0.02    +0.02
Segment Azimuth (degrees)        -0.13    +0.12 *
West Side:
Topographic Altitude (degrees)   +0.05    -0.04
Vegetation Height (ft)          +0.15    -0.18 *
Vegetation Crown (ft)           +0.08    -0.08 *
Vegetation Offset (ft)          -0.08    +0.08 *
```

Vegetation Density (%)	+0.35	-0.35 ***
East Side:		
Topographic Altitude (degrees)	+0.01	-0.01
Vegetation Height (ft)	+0.05	-0.05
Vegetation Crown (ft)	+0.05	-0.05
Vegetation Offset (ft)	-0.03	+0.03
Vegetation Density (%)	+0.21	-0.21 **

Scenario 7. Same as Scenario 5 but cool inflow by 5° F

"SSTEMP (2.0.8)"
"English", "Segment Inflow (cfs)", "30.000"
"English", "Inflow Temperature (°F)", "62.500"
"English", "Segment Outflow (cfs)", "31.500"
"English", "Accretion Temp. (°F)", "55.000"
"English", "Latitude (degrees)", "46.600"
"English", "Segment Length (mi)", "4.420"
"English", "Upstream Elevation (ft)", "3840.00"
"English", "Downstream Elevation (ft)", "3705.00"
"English", "Width's A Term (s/ft²)", "14.400"
"English", " B Term where W = A*Q**B", "0.110"
"English", "Manning's n", "0.032"
"English", "Air Temperature (°F)", "78.440"
"English", "Relative Humidity (%)", "32.800"
"English", "Wind Speed (mph)", "7.100"
"English", "Ground Temperature (°F)", "55.000"
"English", "Thermal gradient (j/m²/s/C)", "1.650"
"English", "Possible Sun (%)", "90.000"
"English", "Dust Coefficient", "5.000"
"English", "Ground Reflectivity (%)", "25.000"
"English", "Solar Radiation (Langleys/d)", "630.940"
"English", "Total Shade (%)", "27.022"
"English", "Segment Azimuth (degrees)", "-45.000"
"West Side Variables"
"English", "Topographic Altitude (degrees)", "25.000"
"English", "Vegetation Height (ft)", "25.000"
"English", "Vegetation Crown (ft)", "10.000"
"English", "Vegetation Offset (ft)", "5.000"
"English", "Vegetation Density (%)", "20.000"
"East Side Variables"
"English", "Segment Azimuth (degrees)", "15.000"
"English", "Topographic Altitude (degrees)", "35.000"
"English", "Vegetation Height (ft)", "15.000"
"English", "Vegetation Crown (ft)", "5.000"
"English", "Vegetation Offset (ft)", "60.000"
"English", " Maximum Air Temp (°F)", "83.422"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
"Predicted Mean (°F) = 65.22"
"Estimated Maximum (°F) = 73.12"
"Approximate Minimum (°F) = 57.32"
"Mean Equilibrium (°F) = 71.43"
"Maximum Equilibrium (°F) = 79.90"
"Minimum Equilibrium (°F) = 62.95"

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 65.22°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity

```
Segment Inflow (cfs)            -0.21    +0.55 ****
Inflow Temperature (°F)          -3.94    +4.11 ******************************
Segment Outflow (cfs)            +0.70    -0.42 *****
Accretion Temp. (°F)            -0.19    +0.19 *
Width's A Term (s/ft²)          -0.26    +0.27 **
  B Term where W = A*Q**B        -0.10    +0.10 *
Manning's n                  +0.00    +0.00
Air Temperature (°F)            -1.92    +1.68 **************
Relative Humidity (%)            -0.29    +0.30 **
Wind Speed (mph)                +0.07    -0.07 *
Ground Temperature (°F)          -0.09    +0.09 *
Thermal gradient (j/m²/s/C)      +0.02    -0.02
Possible Sun (%)               -0.13    +0.18 *
Dust Coefficient               +0.01    -0.01
Ground Reflectivity (%)          -0.01    +0.01
Segment Azimuth (degrees)        -0.07    +0.07 *
West Side:
Topographic Altitude (degrees)   +0.04    -0.03
Vegetation Height (ft)          +0.02    -0.02
Vegetation Crown (ft)            +0.01    -0.01
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)           +0.04    -0.04
East Side:
Topographic Altitude (degrees)   +0.01    -0.01
Vegetation Height (ft)          +0.01    -0.01
Vegetation Crown (ft)            +0.01    -0.01
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)           +0.06    -0.06

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 73.12°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-------------------------------------------------------------------------------
Segment Inflow (cfs)            -0.19    +0.45 ****
Inflow Temperature (°F)          -3.06    +3.19 ******************************
Segment Outflow (cfs)            +0.76    -0.56 *******
Accretion Temp. (°F)            -0.15    +0.15 *
Width's A Term (s/ft²)          -0.51    +0.56 *****
  B Term where W = A*Q**B        -0.20    +0.20 **
Manning's n                  +0.22    -0.24 **
Air Temperature (°F)            -2.24    +2.01 *********************
Relative Humidity (%)            -0.30    +0.30 ***
Wind Speed (mph)                +0.22    -0.23 **
Ground Temperature (°F)          -0.11    +0.11 *
Thermal gradient (j/m²/s/C)      +0.05    -0.05
Possible Sun (%)               -0.49    +0.64 ******
Dust Coefficient               +0.03    -0.03
Ground Reflectivity (%)          -0.03    +0.03
Segment Azimuth (degrees)        -0.22    +0.22 **
West Side:
Topographic Altitude (degrees)   +0.12    -0.09 *
Vegetation Height (ft)          +0.06    -0.06 *
Vegetation Crown (ft)            +0.03    -0.03
Vegetation Offset (ft)          -0.03    +0.03
```

Vegetation Density (%)	+0.13	-0.13 *
East Side:		
Topographic Altitude (degrees)	+0.02	-0.02
Vegetation Height (ft)	+0.04	-0.04
Vegetation Crown (ft)	+0.04	-0.04
Vegetation Offset (ft)	-0.03	+0.03
Vegetation Density (%)	+0.18	-0.18 **

Scenario 8. Same as Scenario 5 but increase vegetation density and cool inflow by 5° F

```
"SSTEMP (2.0.8)"
"English",      "Segment Inflow (cfs)",          "30.000"
"English",      "Inflow Temperature (°F)",       "62.500"
"English",      "Segment Outflow (cfs)",         "31.500"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.600"
"English",      "Segment Length (mi)",           "4.420"
"English",      "Upstream Elevation (ft)",       "3840.00"
"English",      "Downstream Elevation (ft)",     "3705.00"
"English",      "Width's A Term (s/ft²)",        "14.400"
"English",      "  B Term where W = A*Q**B",     "0.110"
"English",      "Manning's n",                   "0.032"
"English",      "Air Temperature (°F)",          "78.440"
"English",      "Relative Humidity (%)",         "32.800"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.940"
"English",      "Total Shade (%)",               "48.807"
"English",      "Segment Azimuth (degrees)",     "-45.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "10.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "60.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "15.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "75.000"
"English",      " Maximum Air Temp (°F)",        "83.422"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
    "Predicted Mean (°F) = 64.27"
    "Estimated Maximum (°F) = 70.16"
    "Approximate Minimum (°F) = 58.39"
    "Mean Equilibrium (°F) = 68.81"
    "Maximum Equilibrium (°F) = 75.77"
    "Minimum Equilibrium (°F) = 61.85"

Sensitivity for mean temperature values (10% variation)    SSTEMP (2.0.8)
Original mean temperature = 64.27°F
                    Temperature change (°F)
                      if variable is:
Variable                Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
```

```
Segment Inflow (cfs)            -0.25    +0.58 ****
Inflow Temperature (°F)          -3.96    +4.12 ******************************
Segment Outflow (cfs)           +0.66    -0.38 *****
Accretion Temp. (°F)            -0.20    +0.20 *
Width's A Term (s/ft²)          -0.24    +0.24 **
 B Term where W = A*Q**B        -0.09    +0.09 *
Manning's n                  +0.00    +0.00
Air Temperature (°F)            -1.91    +1.67 **************
Relative Humidity (%)           -0.28    +0.29 **
Wind Speed (mph)                +0.06    -0.06
Ground Temperature (°F)          -0.09    +0.09 *
Thermal gradient (j/m²/s/C)      +0.02    -0.02
Possible Sun (%)              -0.09    +0.13 *
Dust Coefficient              +0.01    -0.01
Ground Reflectivity (%)          -0.01    +0.01
Segment Azimuth (degrees)        -0.04    +0.04
West Side:
Topographic Altitude (degrees)   +0.02    -0.01
Vegetation Height (ft)          +0.05    -0.06
Vegetation Crown (ft)           +0.03    -0.03
Vegetation Offset (ft)          -0.03    +0.03
Vegetation Density (%)           +0.12    -0.12 *
East Side:
Topographic Altitude (degrees)   +0.00     0.00
Vegetation Height (ft)          +0.02    -0.02
Vegetation Crown (ft)           +0.02    -0.02
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)           +0.07    -0.07 *

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 70.16°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-------------------------------------------------------------------------------
Segment Inflow (cfs)            -0.23    +0.51 ****
Inflow Temperature (°F)          -3.29    +3.43 ******************************
Segment Outflow (cfs)           +0.71    -0.49 ******
Accretion Temp. (°F)            -0.17    +0.17 *
Width's A Term (s/ft²)          -0.54    +0.57 *****
 B Term where W = A*Q**B        -0.22    +0.22 **
Manning's n                  +0.17    -0.19 **
Air Temperature (°F)            -2.21    +1.98 *******************
Relative Humidity (%)           -0.29    +0.29 ***
Wind Speed (mph)                +0.15    -0.16 *
Ground Temperature (°F)          -0.11    +0.11 *
Thermal gradient (j/m²/s/C)      +0.04    -0.04
Possible Sun (%)              -0.36    +0.46 ****
Dust Coefficient              +0.02    -0.02
Ground Reflectivity (%)          -0.02    +0.02
Segment Azimuth (degrees)        -0.13    +0.13 *
West Side:
Topographic Altitude (degrees)   +0.06    -0.04
Vegetation Height (ft)          +0.16    -0.19 **
Vegetation Crown (ft)           +0.08    -0.08 *
Vegetation Offset (ft)          -0.08    +0.08 *
```

Vegetation Density (%)	+0.37	-0.37 ***
East Side:		
Topographic Altitude (degrees)	+0.01	-0.01
Vegetation Height (ft)	+0.05	-0.05
Vegetation Crown (ft)	+0.05	-0.05
Vegetation Offset (ft)	-0.03	+0.03
Vegetation Density (%)	+0.22	-0.22 **

Prickly Pear Segment MT41I006_020

Scenario 1. Current conditions but stop segment at Sierra Road crossing

```
"SSTEMP (2.0.8) "
"English",      "Segment Inflow (cfs)",          "4.000"
"English",      "Inflow Temperature (°F)",       "61.000"
"English",      "Segment Outflow (cfs)",         "7.500"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.700"
"English",      "Segment Length (mi)",           "2.620"
"English",      "Upstream Elevation (ft)",       "3705.00"
"English",      "Downstream Elevation (ft)",     "3680.00"
"English",      "Width's A Term (s/ft²)",        "14.800"
"English",      "  B Term where W = A*Q**B",     "0.190"
"English",      "Manning's n",                   "0.031"
"English",      "Air Temperature (°F)",          "78.730"
"English",      "Relative Humidity (%)",         "32.500"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.326"
"English",      "Total Shade (%)",               "33.179"
"English",      "Segment Azimuth (degrees)",     "15.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "15.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "60.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "10.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "20.000"
"English",      " Maximum Air Temp (°F)",        "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
      "Predicted Mean (°F) = 65.02"
      "Estimated Maximum (°F) = 74.13"
      "Approximate Minimum (°F) = 55.91"
      "Mean Equilibrium (°F) = 70.43"
      "Maximum Equilibrium (°F) = 78.54"
      "Minimum Equilibrium (°F) = 62.33"
```

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 65.02°F

Temperature change (°F)
if variable is:

Variable	Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	-0.25	+0.25	**
Inflow Temperature (°F)	-0.82	+0.90	********
Segment Outflow (cfs)	+0.50	-0.57	*****
Accretion Temp. (°F)	-1.46	+1.46	**********
Width's A Term (s/ft²)	-0.43	+0.46	****
B Term where W = A*Q**B	-0.15	+0.15	*
Manning's n	+0.00	+0.00	
Air Temperature (°F)	-3.53	+3.13	**********
Relative Humidity (%)	-0.54	+0.54	*****
Wind Speed (mph)	+0.13	-0.13	*
Ground Temperature (°F)	-0.17	+0.17	*
Thermal gradient (j/m²/s/C)	+0.03	-0.03	
Possible Sun (%)	-0.22	+0.31	***
Dust Coefficient	+0.02	-0.02	
Ground Reflectivity (%)	-0.02	+0.02	
Segment Azimuth (degrees)	-0.02	+0.02	
West Side:			
Topographic Altitude (degrees)	+0.03	-0.04	
Vegetation Height (ft)	+0.04	-0.05	
Vegetation Crown (ft)	+0.04	-0.04	
Vegetation Offset (ft)	-0.03	+0.03	
Vegetation Density (%)	+0.13	-0.13	*
East Side:			
Topographic Altitude (degrees)	+0.03	-0.03	
Vegetation Height (ft)	+0.02	-0.02	
Vegetation Crown (ft)	+0.01	-0.01	
Vegetation Offset (ft)	-0.01	+0.01	
Vegetation Density (%)	+0.07	-0.07	*

Sensitivity for maximum temperature values (10% varaition) SSTEMP (2.0.8)
Original maximum temperature = 74.13°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	-0.19	+0.19	**
Inflow Temperature (°F)	-0.56	+0.61	*****
Segment Outflow (cfs)	+0.49	-0.54	*****
Accretion Temp. (°F)	-0.99	+0.99	*********
Width's A Term (s/ft²)	-0.59	+0.64	*****
B Term where W = A*Q**B	-0.21	+0.20	**
Manning's n	+0.18	-0.19	**
Air Temperature (°F)	-3.47	+3.17	**********
Relative Humidity (%)	-0.48	+0.49	****
Wind Speed (mph)	+0.34	-0.36	***
Ground Temperature (°F)	-0.18	+0.18	**
Thermal gradient (j/m²/s/C)	+0.07	-0.07	*
Possible Sun (%)	-0.59	+0.78	*******
Dust Coefficient	+0.04	-0.04	
Ground Reflectivity (%)	-0.04	+0.04	
Segment Azimuth (degrees)	-0.05	+0.05	
West Side:			
Topographic Altitude (degrees)	+0.08	-0.08	*
Vegetation Height (ft)	+0.08	-0.11	*

Vegetation Crown (ft)	+0.08	-0.09 *
Vegetation Offset (ft)	-0.06	+0.06 *
Vegetation Density (%)	+0.29	-0.29 ***
East Side:		
Topographic Altitude (degrees)	+0.07	-0.06 *
Vegetation Height (ft)	+0.04	-0.05
Vegetation Crown (ft)	+0.02	-0.02
Vegetation Offset (ft)	-0.02	+0.02
Vegetation Density (%)	+0.15	-0.15 *

Scenario 2. Current conditions to end of segment

"SSTEMP (2.0.8) "
"English", "Segment Inflow (cfs)", "4.000"
"English", "Inflow Temperature (°F)", "61.000"
"English", "Segment Outflow (cfs)", "18.000"
"English", "Accretion Temp. (°F)", "55.000"
"English", "Latitude (degrees)", "46.700"
"English", "Segment Length (mi)", "5.920"
"English", "Upstream Elevation (ft)", "3705.00"
"English", "Downstream Elevation (ft)", "3650.00"
"English", "Width's A Term (s/ft²)", "14.800"
"English", " B Term where W = A*Q**B", "0.190"
"English", "Manning's n", "0.030"
"English", "Air Temperature (°F)", "78.730"
"English", "Relative Humidity (%)", "32.500"
"English", "Wind Speed (mph)", "7.100"
"English", "Ground Temperature (°F)", "55.000"
"English", "Thermal gradient (j/m²/s/C)", "1.650"
"English", "Possible Sun (%)", "90.000"
"English", "Dust Coefficient", "5.000"
"English", "Ground Reflectivity (%)", "25.000"
"English", "Solar Radiation (Langleys/d)", "630.297"
"English", "Total Shade (%)", "31.956"
"English", "Segment Azimuth (degrees)", "15.000"
"West Side Variables"
"English", "Topographic Altitude (degrees)", "25.000"
"English", "Vegetation Height (ft)", "25.000"
"English", "Vegetation Crown (ft)", "15.000"
"English", "Vegetation Offset (ft)", "5.000"
"English", "Vegetation Density (%)", "60.000"
"East Side Variables"
"English", "Segment Azimuth (degrees)", "15.000"
"English", "Topographic Altitude (degrees)", "35.000"
"English", "Vegetation Height (ft)", "10.000"
"English", "Vegetation Crown (ft)", "5.000"
"English", "Vegetation Offset (ft)", "20.000"
"English", " Maximum Air Temp (°F)", "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
"Predicted Mean (°F) = 64.08"
"Estimated Maximum (°F) = 71.99"
"Approximate Minimum (°F) = 56.18"
"Mean Equilibrium (°F) = 70.58"
"Maximum Equilibrium (°F) = 78.77"
"Minimum Equilibrium (°F) = 62.39"

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 64.08°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity

```
Segment Inflow (cfs)            -0.11    +0.11 *
Inflow Temperature (°F)          -0.16    +0.18 **
Segment Outflow (cfs)            +0.38    -0.43 ****
Accretion Temp. (°F)             -2.20    +2.20 ******************
Width's A Term (s/ft²)           -0.44    +0.48 ****
 B Term where W = A*Q**B         -0.21    +0.21 **
Manning's n                  +0.00    +0.00
Air Temperature (°F)             -3.42    +3.04 ****************************
Relative Humidity (%)            -0.52    +0.53 *****
Wind Speed (mph)                 +0.12    -0.12 *
Ground Temperature (°F)          -0.17    +0.17 *
Thermal gradient (j/m²/s/C)      +0.03    -0.03
Possible Sun (%)             -0.22    +0.30 ***
Dust Coefficient             +0.02    -0.02
Ground Reflectivity (%)          -0.02    +0.02
Segment Azimuth (degrees)        -0.02    +0.02
West Side:
Topographic Altitude (degrees)   +0.04    -0.03
Vegetation Height (ft)           +0.04    -0.05
Vegetation Crown (ft)            +0.04    -0.04
Vegetation Offset (ft)           -0.02    +0.02
Vegetation Density (%)           +0.12    -0.12 *
East Side:
Topographic Altitude (degrees)   +0.03    -0.03
Vegetation Height (ft)           +0.02    -0.02
Vegetation Crown (ft)            +0.01    -0.01
Vegetation Offset (ft)           -0.01    +0.01
Vegetation Density (%)           +0.06    -0.06 *

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 71.99°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
Segment Inflow (cfs)            -0.09    +0.09 *
Inflow Temperature (°F)          -0.12    +0.14 *
Segment Outflow (cfs)            +0.48    -0.52 *****
Accretion Temp. (°F)             -1.70    +1.70 ***************
Width's A Term (s/ft²)           -0.66    +0.74 *******
 B Term where W = A*Q**B         -0.31    +0.32 ***
Manning's n                  +0.23    -0.25 **
Air Temperature (°F)             -3.41    +3.11 ****************************
Relative Humidity (%)            -0.48    +0.48 ****
Wind Speed (mph)                 +0.25    -0.27 **
Ground Temperature (°F)          -0.17    +0.17 **
Thermal gradient (j/m²/s/C)      +0.06    -0.06 *
Possible Sun (%)             -0.55    +0.73 ******
Dust Coefficient             +0.03    -0.03
Ground Reflectivity (%)          -0.04    +0.03
Segment Azimuth (degrees)        -0.05    +0.05
West Side:
Topographic Altitude (degrees)   +0.08    -0.07 *
Vegetation Height (ft)           +0.09    -0.10 *
Vegetation Crown (ft)            +0.08    -0.08 *
Vegetation Offset (ft)           -0.05    +0.05
```

Vegetation Density (%)	+0.26	-0.26 **
East Side:		
Topographic Altitude (degrees)	+0.07	-0.06 *
Vegetation Height (ft)	+0.04	-0.04
Vegetation Crown (ft)	+0.02	-0.02
Vegetation Offset (ft)	-0.02	+0.02
Vegetation Density (%)	+0.14	-0.14 *

Scenario 3. Same as Scenario 2 but increase vegetation density

```
"SSTEMP (2.0.8)  "
"English",      "Segment Inflow (cfs)",          "4.000"
"English",      "Inflow Temperature (°F)",       "61.000"
"English",      "Segment Outflow (cfs)",         "18.000"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.700"
"English",      "Segment Length (mi)",           "5.920"
"English",      "Upstream Elevation (ft)",       "3705.00"
"English",      "Downstream Elevation (ft)",     "3650.00"
"English",      "Width's A Term (s/ft²)",        "14.800"
"English",      "  B Term where W = A*Q**B",     "0.190"
"English",      "Manning's n",                   "0.030"
"English",      "Air Temperature (°F)",          "78.730"
"English",      "Relative Humidity (%)",         "32.500"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.297"
"English",      "Total Shade (%)",               "52.106"
"English",      "Segment Azimuth (degrees)",     "15.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "15.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "75.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "10.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "60.000"
"English",      " Maximum Air Temp (°F)",        "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
      "Predicted Mean (°F) = 62.52"
      "Estimated Maximum (°F) = 68.58"
      "Approximate Minimum (°F) = 56.45"
      "Mean Equilibrium (°F) = 68.13"
      "Maximum Equilibrium (°F) = 74.86"
      "Minimum Equilibrium (°F) = 61.39"

Sensitivity for mean temperature values (10% variation)    SSTEMP (2.0.8)
Original mean temperature = 62.52°F
                        Temperature change (°F)
                           if variable is:
Variable                   Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------
```

Segment Inflow (cfs)	-0.10	+0.10	*
Inflow Temperature (°F)	-0.17	+0.19	**
Segment Outflow (cfs)	+0.31	-0.35	***
Accretion Temp. (°F)	-2.26	+2.26	**********
Width's A Term (s/ft²)	-0.42	+0.47	****
B Term where W = A*Q**B	-0.20	+0.20	**
Manning's n	+0.00	+0.00	
Air Temperature (°F)	-3.43	+3.05	**********
Relative Humidity (%)	-0.51	+0.52	*****
Wind Speed (mph)	+0.08	-0.08	*
Ground Temperature (°F)	-0.17	+0.17	*
Thermal gradient (j/m²/s/C)	+0.02	-0.02	
Possible Sun (%)	-0.15	+0.21	**
Dust Coefficient	+0.01	-0.01	
Ground Reflectivity (%)	-0.01	+0.01	
Segment Azimuth (degrees)	-0.01	+0.01	
West Side:			
Topographic Altitude (degrees)	+0.03	-0.02	
Vegetation Height (ft)	+0.05	-0.06	*
Vegetation Crown (ft)	+0.05	-0.05	
Vegetation Offset (ft)	-0.03	+0.03	
Vegetation Density (%)	+0.15	-0.15	*
East Side:			
Topographic Altitude (degrees)	+0.02	-0.01	
Vegetation Height (ft)	+0.05	-0.05	
Vegetation Crown (ft)	+0.02	-0.02	
Vegetation Offset (ft)	-0.02	+0.02	
Vegetation Density (%)	+0.19	-0.19	**

Sensitivity for maximum temperature values (10% varaition) SSTEMP (2.0.8)
Original maximum temperature = 68.58°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity
Segment Inflow (cfs)	-0.09	+0.09	*
Inflow Temperature (°F)	-0.14	+0.16	*
Segment Outflow (cfs)	+0.39	-0.43	****
Accretion Temp. (°F)	-1.87	+1.87	**********
Width's A Term (s/ft²)	-0.69	+0.77	*******
B Term where W = A*Q**B	-0.33	+0.33	***
Manning's n	+0.18	-0.20	**
Air Temperature (°F)	-3.49	+3.15	**********
Relative Humidity (%)	-0.48	+0.48	****
Wind Speed (mph)	+0.17	-0.18	**
Ground Temperature (°F)	-0.18	+0.18	**
Thermal gradient (j/m²/s/C)	+0.05	-0.05	
Possible Sun (%)	-0.42	+0.54	*****
Dust Coefficient	+0.02	-0.02	
Ground Reflectivity (%)	-0.02	+0.02	
Segment Azimuth (degrees)	-0.02	+0.02	
West Side:			
Topographic Altitude (degrees)	+0.06	-0.05	
Vegetation Height (ft)	+0.12	-0.13	*
Vegetation Crown (ft)	+0.10	-0.10	*
Vegetation Offset (ft)	-0.07	+0.07	*

Vegetation Density (%)	+0.33	-0.33 ***
East Side:		
Topographic Altitude (degrees)	+0.04	-0.03
Vegetation Height (ft)	+0.12	-0.12 *
Vegetation Crown (ft)	+0.05	-0.05
Vegetation Offset (ft)	-0.05	+0.05
Vegetation Density (%)	+0.42	-0.42 ****

Scenario 4. Modeling using output from MT41I006_030 – Scenario 5*

```
"SSTEMP (2.0.8) "
"English",      "Segment Inflow (cfs)",          "34.000"
"English",      "Inflow Temperature (°F)",       "67.910"
"English",      "Segment Outflow (cfs)",         "48.000"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.700"
"English",      "Segment Length (mi)",           "5.920"
"English",      "Upstream Elevation (ft)",       "3705.00"
"English",      "Downstream Elevation (ft)",     "3650.00"
"English",      "Width's A Term (s/ft²)",        "14.800"
"English",      "  B Term where W = A*Q**B",     "0.190"
"English",      "Manning's n",                   "0.030"
"English",      "Air Temperature (°F)",          "78.730"
"English",      "Relative Humidity (%)",         "32.500"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.297"
"English",      "Total Shade (%)",               "29.369"
"English",      "Segment Azimuth (degrees)",     "15.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "15.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "60.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "10.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "20.000"
"English",      " Maximum Air Temp (°F)",        "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
      "Predicted Mean (°F) = 66.30"
      "Estimated Maximum (°F) = 72.34"
      "Approximate Minimum (°F) = 60.27"
      "Mean Equilibrium (°F) = 70.96"
      "Maximum Equilibrium (°F) = 79.31"
      "Minimum Equilibrium (°F) = 62.62"

Sensitivity for mean temperature values (10% variation)    SSTEMP (2.0.8)
Original mean temperature = 66.30°F
                    Temperature change (°F)
                      if variable is:
Variable                Decreased Increased  Relative Sensitivity
-----------------------------------------------------------------------------
```

```
Segment Inflow (cfs)            -0.71    +0.70 ********
Inflow Temperature (°F)          -2.34    +2.57 ******************************
Segment Outflow (cfs)            +0.77    -0.90 ***********
Accretion Temp. (°F)            -1.22    +1.24 **************
Width's A Term (s/ft²)          -0.22    +0.23 ***
 B Term where W = A*Q**B        -0.16    +0.15 **
Manning's n                  +0.00    +0.00
Air Temperature (°F)            -2.38    +2.05 ****************************
Relative Humidity (%)            -0.36    +0.36 ****
Wind Speed (mph)                +0.13    -0.13 **
Ground Temperature (°F)          -0.12    +0.12 *
Thermal gradient (j/m²/s/C)      +0.03    -0.03
Possible Sun (%)               -0.15    +0.22 ***
Dust Coefficient               +0.01    -0.01
Ground Reflectivity (%)          -0.01    +0.01
Segment Azimuth (degrees)        -0.01    +0.01
West Side:
Topographic Altitude (degrees)   +0.02    -0.02
Vegetation Height (ft)          +0.03    -0.04
Vegetation Crown (ft)           +0.02    -0.02
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)           +0.07    -0.07 *
East Side:
Topographic Altitude (degrees)   +0.02    -0.02
Vegetation Height (ft)          +0.02    -0.02
Vegetation Crown (ft)           +0.01    -0.01
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)           +0.04    -0.04

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 72.34°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-------------------------------------------------------------------------------
Segment Inflow (cfs)            -0.62    +0.62 *******
Inflow Temperature (°F)          -1.97    +2.16 *************************
Segment Outflow (cfs)            +0.84    -0.96 ***********
Accretion Temp. (°F)            -1.03    +1.04 ************
Width's A Term (s/ft²)          -0.49    +0.52 ******
 B Term where W = A*Q**B        -0.36    +0.35 ****
Manning's n                  +0.21    -0.24 ***
Air Temperature (°F)            -2.55    +2.26 ******************************
Relative Humidity (%)            -0.35    +0.35 ****
Wind Speed (mph)                +0.21    -0.22 ***
Ground Temperature (°F)          -0.13    +0.13 *
Thermal gradient (j/m²/s/C)      +0.04    -0.04 *
Possible Sun (%)               -0.43    +0.57 *******
Dust Coefficient               +0.03    -0.03
Ground Reflectivity (%)          -0.03    +0.03
Segment Azimuth (degrees)        -0.03    +0.03
West Side:
Topographic Altitude (degrees)   +0.06    -0.06 *
Vegetation Height (ft)          +0.08    -0.09 *
Vegetation Crown (ft)           +0.05    -0.05 *
Vegetation Offset (ft)          -0.03    +0.03
```

Vegetation Density (%)	+0.17	-0.17 **
East Side:		
Topographic Altitude (degrees)	+0.05	-0.04 *
Vegetation Height (ft)	+0.04	-0.04
Vegetation Crown (ft)	+0.01	-0.01
Vegetation Offset (ft)	-0.01	+0.01
Vegetation Density (%)	+0.09	-0.09 *

Scenario 5. Modeling using output from MT411006_030 – Scenario 5 and increase vegetation density in segment MT411006_020*

"SSTEMP (2.0.8) "
"English", "Segment Inflow (cfs)", "34.000"
"English", "Inflow Temperature (°F)", "67.910"
"English", "Segment Outflow (cfs)", "48.000"
"English", "Accretion Temp. (°F)", "55.000"
"English", "Latitude (degrees)", "46.700"
"English", "Segment Length (mi)", "5.920"
"English", "Upstream Elevation (ft)", "3705.00"
"English", "Downstream Elevation (ft)", "3650.00"
"English", "Width's A Term (s/ft²)", "14.800"
"English", " B Term where W = A*Q**B", "0.190"
"English", "Manning's n", "0.030"
"English", "Air Temperature (°F)", "78.730"
"English", "Relative Humidity (%)", "32.500"
"English", "Wind Speed (mph)", "7.100"
"English", "Ground Temperature (°F)", "55.000"
"English", "Thermal gradient (j/m²/s/C)", "1.650"
"English", "Possible Sun (%)", "90.000"
"English", "Dust Coefficient", "5.000"
"English", "Ground Reflectivity (%)", "25.000"
"English", "Solar Radiation (Langleys/d)", "630.297"
"English", "Total Shade (%)", "47.689"
"English", "Segment Azimuth (degrees)", "15.000"
"West Side Variables"
"English", "Topographic Altitude (degrees)", "25.000"
"English", "Vegetation Height (ft)", "25.000"
"English", "Vegetation Crown (ft)", "15.000"
"English", "Vegetation Offset (ft)", "5.000"
"English", "Vegetation Density (%)", "75.000"
"East Side Variables"
"English", "Segment Azimuth (degrees)", "15.000"
"English", "Topographic Altitude (degrees)", "35.000"
"English", "Vegetation Height (ft)", "10.000"
"English", "Vegetation Crown (ft)", "5.000"
"English", "Vegetation Offset (ft)", "60.000"
"English", " Maximum Air Temp (°F)", "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
"Predicted Mean (°F) = 65.33"
"Estimated Maximum (°F) = 70.04"
"Approximate Minimum (°F) = 60.63"
"Mean Equilibrium (°F) = 68.76"
"Maximum Equilibrium (°F) = 75.82"
"Minimum Equilibrium (°F) = 61.70"

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 65.33°F

Variable	Temperature change (°F) if variable is: Decreased	Increased	Relative Sensitivity

```
-----------------------------------------------------------------------------
Segment Inflow (cfs)            -0.71    +0.71 ********
Inflow Temperature (°F)          -2.36    +2.59 ******************************
Segment Outflow (cfs)           +0.72    -0.84 **********
Accretion Temp. (°F)            -1.25    +1.27 ***************
Width's A Term (s/ft²)          -0.20    +0.20 **
 B Term where W = A*Q**B        -0.15    +0.14 **
Manning's n                  +0.00    +0.00
Air Temperature (°F)            -2.35    +2.03 ***************************
Relative Humidity (%)           -0.35    +0.38 ****
Wind Speed (mph)                +0.11    -0.12 *
Ground Temperature (°F)          -0.12    +0.11 *
Thermal gradient (j/m²/s/C)      +0.02    -0.02
Possible Sun (%)              -0.11    +0.16 **
Dust Coefficient              +0.01    -0.01
Ground Reflectivity (%)          -0.01    +0.01
Segment Azimuth (degrees)        -0.01    +0.01
West Side:
Topographic Altitude (degrees)   +0.01    -0.02
Vegetation Height (ft)          +0.04    -0.05 *
Vegetation Crown (ft)           +0.03    -0.03
Vegetation Offset (ft)          -0.02    +0.02
Vegetation Density (%)           +0.09    -0.09 *
East Side:
Topographic Altitude (degrees)   +0.01    -0.01
Vegetation Height (ft)          +0.04    -0.04 *
Vegetation Crown (ft)           +0.02    -0.02
Vegetation Offset (ft)          -0.02    +0.02
Vegetation Density (%)           +0.12    -0.12 *

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 70.04°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
Segment Inflow (cfs)            -0.65    +0.65 ********
Inflow Temperature (°F)          -2.07    +2.27 ***************************
Segment Outflow (cfs)           +0.77    -0.89 ***********
Accretion Temp. (°F)            -1.10    +1.11 *************
Width's A Term (s/ft²)          -0.49    +0.51 ******
 B Term where W = A*Q**B        -0.36    +0.34 ****
Manning's n                  +0.17    -0.19 **
Air Temperature (°F)            -2.53    +2.23 ******************************
Relative Humidity (%)           -0.34    +0.38 ****
Wind Speed (mph)                +0.16    -0.17 **
Ground Temperature (°F)          -0.13    +0.13 *
Thermal gradient (j/m²/s/C)      +0.04    -0.04
Possible Sun (%)              -0.33    +0.43 *****
Dust Coefficient              +0.02    -0.02
Ground Reflectivity (%)          -0.02    +0.02
Segment Azimuth (degrees)        -0.02    +0.01
West Side:
Topographic Altitude (degrees)   +0.03    -0.04
Vegetation Height (ft)          +0.09    -0.11 *
Vegetation Crown (ft)           +0.06    -0.07 *
```

Vegetation Offset (ft)	-0.04	+0.04 *
Vegetation Density (%)	+0.21	-0.21 **
East Side:		
Topographic Altitude (degrees)	+0.03	-0.02
Vegetation Height (ft)	+0.11	-0.11 *
Vegetation Crown (ft)	+0.04	-0.04
Vegetation Offset (ft)	-0.04	+0.04
Vegetation Density (%)	+0.28	-0.28 ***

Scenario 6. Modeling using output from MT411006_030 – Scenario 7*

```
"SSTEMP (2.0.8)  "
"English",      "Segment Inflow (cfs)",          "34.000"
"English",      "Inflow Temperature (°F)",       "64.980"
"English",      "Segment Outflow (cfs)",         "48.000"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.700"
"English",      "Segment Length (mi)",           "5.920"
"English",      "Upstream Elevation (ft)",       "3705.00"
"English",      "Downstream Elevation (ft)",     "3650.00"
"English",      "Width's A Term (s/ft²)",        "14.800"
"English",      "  B Term where W = A*Q**B",     "0.190"
"English",      "Manning's n",                   "0.030"
"English",      "Air Temperature (°F)",          "78.730"
"English",      "Relative Humidity (%)",         "32.500"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.297"
"English",      "Total Shade (%)",               "29.369"
"English",      "Segment Azimuth (degrees)",     "15.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "15.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "60.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "10.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "20.000"
"English",      " Maximum Air Temp (°F)",        "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
      "Predicted Mean (°F) = 65.22"
      "Estimated Maximum (°F) = 71.43"
      "Approximate Minimum (°F) = 59.02"
      "Mean Equilibrium (°F) = 70.96"
      "Maximum Equilibrium (°F) = 79.31"
      "Minimum Equilibrium (°F) = 62.62"

Sensitivity for mean temperature values (10% variation)    SSTEMP (2.0.8)
Original mean temperature = 65.22°F
                        Temperature change (°F)
                           if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
```

```
Segment Inflow (cfs)          -0.56    +0.56 *******
Inflow Temperature (°F)        -2.34    +2.54 ******************************
Segment Outflow (cfs)          +0.68    -0.80 *********
Accretion Temp. (°F)           -1.19    +1.21 **************
Width's A Term (s/ft²)         -0.29    +0.29 ***
 B Term where W = A*Q**B       -0.21    +0.20 **
Manning's n                  +0.00    +0.00
Air Temperature (°F)           -2.40    +2.07 ****************************
Relative Humidity (%)          -0.36    +0.36 ****
Wind Speed (mph)               +0.10    -0.10 *
Ground Temperature (°F)        -0.12    +0.12 *
Thermal gradient (j/m²/s/C)    +0.02    -0.02
Possible Sun (%)             -0.16    +0.22 ***
Dust Coefficient             +0.01    -0.01
Ground Reflectivity (%)        -0.01    +0.01
Segment Azimuth (degrees)      -0.01    +0.01
West Side:
Topographic Altitude (degrees)  +0.02    -0.02
Vegetation Height (ft)         +0.03    -0.04
Vegetation Crown (ft)          +0.02    -0.02
Vegetation Offset (ft)         -0.01    +0.01
Vegetation Density (%)         +0.07    -0.07 *
East Side:
Topographic Altitude (degrees)  +0.02    -0.02
Vegetation Height (ft)         +0.02    -0.02
Vegetation Crown (ft)          +0.01    -0.01
Vegetation Offset (ft)         -0.01    +0.01
Vegetation Density (%)         +0.04    -0.04

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 71.43°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased  Relative Sensitivity
-------------------------------------------------------------------------------
Segment Inflow (cfs)          -0.50    +0.50 ******
Inflow Temperature (°F)        -1.97    +2.14 *************************
Segment Outflow (cfs)          +0.77    -0.88 **********
Accretion Temp. (°F)           -1.01    +1.02 ************
Width's A Term (s/ft²)         -0.55    +0.59 *******
 B Term where W = A*Q**B       -0.41    +0.39 *****
Manning's n                  +0.22    -0.25 ***
Air Temperature (°F)           -2.58    +2.28 ******************************
Relative Humidity (%)          -0.35    +0.36 ****
Wind Speed (mph)               +0.19    -0.20 **
Ground Temperature (°F)        -0.13    +0.13 *
Thermal gradient (j/m²/s/C)    +0.04    -0.04
Possible Sun (%)             -0.44    +0.58 *******
Dust Coefficient             +0.03    -0.03
Ground Reflectivity (%)        -0.03    +0.03
Segment Azimuth (degrees)      -0.03    +0.03
West Side:
Topographic Altitude (degrees)  +0.06    -0.06 *
Vegetation Height (ft)         +0.08    -0.09 *
Vegetation Crown (ft)          +0.05    -0.06 *
Vegetation Offset (ft)         -0.04    +0.04
```

Vegetation Density (%)	+0.17	-0.17 **
East Side:		
Topographic Altitude (degrees)	+0.05	-0.05 *
Vegetation Height (ft)	+0.04	-0.04
Vegetation Crown (ft)	+0.01	-0.01
Vegetation Offset (ft)	-0.01	+0.01
Vegetation Density (%)	+0.10	-0.10 *

Scenario 7. Modeling using output from MT411006_030 – Scenario 7 and increase vegetation density in segment MT411006_020*

"SSTEMP (2.0.8) "
"English", "Segment Inflow (cfs)", "34.000"
"English", "Inflow Temperature (°F)", "64.980"
"English", "Segment Outflow (cfs)", "48.000"
"English", "Accretion Temp. (°F)", "55.000"
"English", "Latitude (degrees)", "46.700"
"English", "Segment Length (mi)", "5.920"
"English", "Upstream Elevation (ft)", "3705.00"
"English", "Downstream Elevation (ft)", "3650.00"
"English", "Width's A Term (s/ft²)", "14.800"
"English", " B Term where W = A*Q**B", "0.190"
"English", "Manning's n", "0.030"
"English", "Air Temperature (°F)", "78.730"
"English", "Relative Humidity (%)", "32.500"
"English", "Wind Speed (mph)", "7.100"
"English", "Ground Temperature (°F)", "55.000"
"English", "Thermal gradient (j/m²/s/C)", "1.650"
"English", "Possible Sun (%)", "90.000"
"English", "Dust Coefficient", "5.000"
"English", "Ground Reflectivity (%)", "25.000"
"English", "Solar Radiation (Langleys/d)", "630.297"
"English", "Total Shade (%)", "47.689"
"English", "Segment Azimuth (degrees)", "15.000"
"West Side Variables"
"English", "Topographic Altitude (degrees)", "25.000"
"English", "Vegetation Height (ft)", "25.000"
"English", "Vegetation Crown (ft)", "15.000"
"English", "Vegetation Offset (ft)", "5.000"
"English", "Vegetation Density (%)", "75.000"
"East Side Variables"
"English", "Segment Azimuth (degrees)", "15.000"
"English", "Topographic Altitude (degrees)", "35.000"
"English", "Vegetation Height (ft)", "10.000"
"English", "Vegetation Crown (ft)", "5.000"
"English", "Vegetation Offset (ft)", "60.000"
"English", " Maximum Air Temp (°F)", "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
"Predicted Mean (°F) = 64.24"
"Estimated Maximum (°F) = 69.08"
"Approximate Minimum (°F) = 59.41"
"Mean Equilibrium (°F) = 68.76"
"Maximum Equilibrium (°F) = 75.82"
"Minimum Equilibrium (°F) = 61.70"

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 64.24°F

	Temperature change (°F) if variable is:		
Variable	Decreased	Increased	Relative Sensitivity

```
-----------------------------------------------------------------------------
Segment Inflow (cfs)            -0.56    +0.56 *******
Inflow Temperature (°F)          -2.36    +2.56 ******************************
Segment Outflow (cfs)            +0.63    -0.74 *********
Accretion Temp. (°F)            -1.22    +1.24 ***************
Width's A Term (s/ft²)          -0.26    +0.27 ***
  B Term where W = A*Q**B        -0.19    +0.18 **
Manning's n                  +0.00    +0.00
Air Temperature (°F)            -2.38    +2.05 ****************************
Relative Humidity (%)            -0.35    +0.35 ****
Wind Speed (mph)                +0.09    -0.09 *
Ground Temperature (°F)          -0.12    +0.12 *
Thermal gradient (j/m²/s/C)      +0.02    -0.02
Possible Sun (%)               -0.11    +0.16 **
Dust Coefficient               +0.01    -0.01
Ground Reflectivity (%)          -0.01    +0.01
Segment Azimuth (degrees)        -0.01    +0.01
West Side:
Topographic Altitude (degrees)   +0.01    -0.02
Vegetation Height (ft)          +0.04    -0.05 *
Vegetation Crown (ft)            +0.03    -0.03
Vegetation Offset (ft)          -0.02    +0.02
Vegetation Density (%)           +0.09    -0.09 *
East Side:
Topographic Altitude (degrees)   +0.01    -0.01
Vegetation Height (ft)          +0.05    -0.05 *
Vegetation Crown (ft)            +0.02    -0.02
Vegetation Offset (ft)          -0.02    +0.02
Vegetation Density (%)           +0.12    -0.12 *

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 69.08°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
Segment Inflow (cfs)            -0.52    +0.52 ******
Inflow Temperature (°F)          -2.07    +2.25 *************************
Segment Outflow (cfs)            +0.70    -0.80 *********
Accretion Temp. (°F)            -1.07    +1.09 *************
Width's A Term (s/ft²)          -0.55    +0.58 *******
  B Term where W = A*Q**B        -0.41    +0.39 *****
Manning's n                  +0.18    -0.20 **
Air Temperature (°F)            -2.56    +2.25 ******************************
Relative Humidity (%)            -0.35    +0.35 ****
Wind Speed (mph)                +0.14    -0.15 **
Ground Temperature (°F)          -0.13    +0.13 *
Thermal gradient (j/m²/s/C)      +0.04    -0.04
Possible Sun (%)               -0.34    +0.44 *****
Dust Coefficient               +0.02    -0.02
Ground Reflectivity (%)          -0.02    +0.02
Segment Azimuth (degrees)        -0.02    +0.01
West Side:
Topographic Altitude (degrees)   +0.03    -0.04
Vegetation Height (ft)          +0.09    -0.12 *
Vegetation Crown (ft)            +0.07    -0.07 *
```

Vegetation Offset (ft)	-0.04	+0.04 *
Vegetation Density (%)	+0.21	-0.21 **
East Side:		
Topographic Altitude (degrees)	+0.03	-0.02
Vegetation Height (ft)	+0.11	-0.11 *
Vegetation Crown (ft)	+0.04	-0.04
Vegetation Offset (ft)	-0.04	+0.04
Vegetation Density (%)	+0.29	-0.29 ***

Scenario 8. Modeling using output from MT41I006_030 – Scenario 8*

```
"SSTEMP (2.0.8)  "
"English",      "Segment Inflow (cfs)",          "34.000"
"English",      "Inflow Temperature (°F)",       "64.100"
"English",      "Segment Outflow (cfs)",         "48.000"
"English",      "Accretion Temp. (°F)",          "55.000"
"English",      "Latitude (degrees)",            "46.700"
"English",      "Segment Length (mi)",           "5.920"
"English",      "Upstream Elevation (ft)",       "3705.00"
"English",      "Downstream Elevation (ft)",     "3650.00"
"English",      "Width's A Term (s/ft²)",        "14.800"
"English",      "  B Term where W = A*Q**B",     "0.190"
"English",      "Manning's n",                   "0.030"
"English",      "Air Temperature (°F)",          "78.730"
"English",      "Relative Humidity (%)",         "32.500"
"English",      "Wind Speed (mph)",              "7.100"
"English",      "Ground Temperature (°F)",       "55.000"
"English",      "Thermal gradient (j/m²/s/C)",   "1.650"
"English",      "Possible Sun (%)",              "90.000"
"English",      "Dust Coefficient",              "5.000"
"English",      "Ground Reflectivity (%)",       "25.000"
"English",      "Solar Radiation (Langleys/d)",  "630.297"
"English",      "Total Shade (%)",               "29.369"
"English",      "Segment Azimuth (degrees)",     "15.000"
"West Side Variables"
"English",      "Topographic Altitude (degrees)", "25.000"
"English",      "Vegetation Height (ft)",        "25.000"
"English",      "Vegetation Crown (ft)",         "15.000"
"English",      "Vegetation Offset (ft)",        "5.000"
"English",      "Vegetation Density (%)",        "60.000"
"East Side Variables"
"English",      "Segment Azimuth (degrees)",     "15.000"
"English",      "Topographic Altitude (degrees)", "35.000"
"English",      "Vegetation Height (ft)",        "10.000"
"English",      "Vegetation Crown (ft)",         "5.000"
"English",      "Vegetation Offset (ft)",        "20.000"
"English",      " Maximum Air Temp (°F)",        "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
      "Predicted Mean (°F) = 64.89"
      "Estimated Maximum (°F) = 71.15"
      "Approximate Minimum (°F) = 58.63"
      "Mean Equilibrium (°F) = 70.96"
      "Maximum Equilibrium (°F) = 79.31"
      "Minimum Equilibrium (°F) = 62.62"

Sensitivity for mean temperature values (10% variation)    SSTEMP (2.0.8)
Original mean temperature = 64.89°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
```

```
Segment Inflow (cfs)            -0.51    +0.51 ******
Inflow Temperature (°F)          -2.34    +2.53 ******************************
Segment Outflow (cfs)            +0.66    -0.77 *********
Accretion Temp. (°F)             -1.19    +1.20 **************
Width's A Term (s/ft²)           -0.31    +0.31 ****
 B Term where W = A*Q**B         -0.22    +0.21 ***
Manning's n                     +0.00    +0.00
Air Temperature (°F)             -2.41    +2.08 ****************************
Relative Humidity (%)            -0.36    +0.36 ****
Wind Speed (mph)                 +0.09    -0.10 *
Ground Temperature (°F)          -0.12    +0.12 *
Thermal gradient (j/m²/s/C)      +0.02    -0.02
Possible Sun (%)                -0.16    +0.22 ***
Dust Coefficient                +0.01    -0.01
Ground Reflectivity (%)          -0.01    +0.01
Segment Azimuth (degrees)        -0.01    +0.01
West Side:
Topographic Altitude (degrees)   +0.02    -0.02
Vegetation Height (ft)           +0.03    -0.04
Vegetation Crown (ft)            +0.02    -0.02
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)           +0.07    -0.07 *
East Side:
Topographic Altitude (degrees)   +0.02    -0.02
Vegetation Height (ft)           +0.02    -0.02
Vegetation Crown (ft)            +0.01    -0.01
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)           +0.04    -0.04

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 71.15°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased   Relative Sensitivity
-------------------------------------------------------------------------------
Segment Inflow (cfs)            -0.46    +0.46 *****
Inflow Temperature (°F)          -1.97    +2.13 *************************
Segment Outflow (cfs)            +0.75    -0.85 **********
Accretion Temp. (°F)             -1.00    +1.02 ************
Width's A Term (s/ft²)           -0.57    +0.61 *******
 B Term where W = A*Q**B         -0.42    +0.41 *****
Manning's n                     +0.22    -0.25 ***
Air Temperature (°F)             -2.59    +2.29 ******************************
Relative Humidity (%)            -0.35    +0.36 ****
Wind Speed (mph)                 +0.18    -0.19 **
Ground Temperature (°F)          -0.13    +0.13 *
Thermal gradient (j/m²/s/C)      +0.04    -0.04
Possible Sun (%)                -0.44    +0.58 *******
Dust Coefficient                +0.03    -0.03
Ground Reflectivity (%)          -0.03    +0.03
Segment Azimuth (degrees)        -0.03    +0.03
West Side:
Topographic Altitude (degrees)   +0.06    -0.06 *
Vegetation Height (ft)           +0.08    -0.10 *
Vegetation Crown (ft)            +0.05    -0.06 *
Vegetation Offset (ft)          -0.04    +0.04
```

Vegetation Density (%)	+0.17	-0.17 **
East Side:		
Topographic Altitude (degrees)	+0.05	-0.05 *
Vegetation Height (ft)	+0.04	-0.04
Vegetation Crown (ft)	+0.01	-0.01
Vegetation Offset (ft)	-0.01	+0.01
Vegetation Density (%)	+0.10	-0.10 *

Scenario 9. Modeling using output from MT411006_030 – Scenario 8 and increase vegetation density in segment MT411006_020*

"SSTEMP (2.0.8) "
"English", "Segment Inflow (cfs)", "34.000"
"English", "Inflow Temperature (°F)", "64.100"
"English", "Segment Outflow (cfs)", "48.000"
"English", "Accretion Temp. (°F)", "55.000"
"English", "Latitude (degrees)", "46.700"
"English", "Segment Length (mi)", "5.920"
"English", "Upstream Elevation (ft)", "3705.00"
"English", "Downstream Elevation (ft)", "3650.00"
"English", "Width's A Term (s/ft²)", "14.800"
"English", " B Term where W = A*Q**B", "0.190"
"English", "Manning's n", "0.030"
"English", "Air Temperature (°F)", "78.730"
"English", "Relative Humidity (%)", "32.500"
"English", "Wind Speed (mph)", "7.100"
"English", "Ground Temperature (°F)", "55.000"
"English", "Thermal gradient (j/m²/s/C)", "1.650"
"English", "Possible Sun (%)", "90.000"
"English", "Dust Coefficient", "5.000"
"English", "Ground Reflectivity (%)", "25.000"
"English", "Solar Radiation (Langleys/d)", "630.297"
"English", "Total Shade (%)", "47.689"
"English", "Segment Azimuth (degrees)", "15.000"
"West Side Variables"
"English", "Topographic Altitude (degrees)", "25.000"
"English", "Vegetation Height (ft)", "25.000"
"English", "Vegetation Crown (ft)", "15.000"
"English", "Vegetation Offset (ft)", "5.000"
"English", "Vegetation Density (%)", "75.000"
"East Side Variables"
"English", "Segment Azimuth (degrees)", "15.000"
"English", "Topographic Altitude (degrees)", "35.000"
"English", "Vegetation Height (ft)", "10.000"
"English", "Vegetation Crown (ft)", "5.000"
"English", "Vegetation Offset (ft)", "60.000"
"English", " Maximum Air Temp (°F)", "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
"Predicted Mean (°F) = 63.91"
"Estimated Maximum (°F) = 68.79"
"Approximate Minimum (°F) = 59.03"
"Mean Equilibrium (°F) = 68.76"
"Maximum Equilibrium (°F) = 75.82"
"Minimum Equilibrium (°F) = 61.70"

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 63.91°F

	Temperature change (°F) if variable is:		
Variable	Decreased	Increased	Relative Sensitivity

```
-----------------------------------------------------------------------------
Segment Inflow (cfs)            -0.52    +0.52 ******
Inflow Temperature (°F)          -2.36    +2.55 ******************************
Segment Outflow (cfs)            +0.60    -0.70 ********
Accretion Temp. (°F)            -1.22    +1.23 ***************
Width's A Term (s/ft²)          -0.28    +0.29 ***
  B Term where W = A*Q**B        -0.21    +0.19 **
Manning's n                  +0.00    +0.00
Air Temperature (°F)            -2.39    +2.06 ****************************
Relative Humidity (%)            -0.35    +0.35 ****
Wind Speed (mph)                +0.08    -0.08 *
Ground Temperature (°F)          -0.12    +0.12 *
Thermal gradient (j/m²/s/C)      +0.02    -0.02
Possible Sun (%)               -0.11    +0.16 **
Dust Coefficient               +0.01    -0.01
Ground Reflectivity (%)          -0.01    +0.01
Segment Azimuth (degrees)        -0.01    +0.01
West Side:
Topographic Altitude (degrees)   +0.01    -0.02
Vegetation Height (ft)          +0.04    -0.05 *
Vegetation Crown (ft)            +0.03    -0.03
Vegetation Offset (ft)          -0.02    +0.02
Vegetation Density (%)           +0.09    -0.09 *
East Side:
Topographic Altitude (degrees)   +0.01    -0.01
Vegetation Height (ft)          +0.05    -0.05 *
Vegetation Crown (ft)            +0.02    -0.02
Vegetation Offset (ft)          -0.02    +0.02
Vegetation Density (%)           +0.12    -0.12 *

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 68.79°F
                        Temperature change (°F)
                          if variable is:
Variable                  Decreased Increased  Relative Sensitivity
-----------------------------------------------------------------------------
Segment Inflow (cfs)            -0.48    +0.48 ******
Inflow Temperature (°F)          -2.07    +2.24 **************************
Segment Outflow (cfs)            +0.67    -0.77 *********
Accretion Temp. (°F)            -1.07    +1.08 *************
Width's A Term (s/ft²)          -0.57    +0.60 *******
  B Term where W = A*Q**B        -0.42    +0.41 *****
Manning's n                  +0.18    -0.20 **
Air Temperature (°F)            -2.57    +2.26 ******************************
Relative Humidity (%)            -0.35    +0.35 ****
Wind Speed (mph)                +0.13    -0.14 **
Ground Temperature (°F)          -0.13    +0.13 *
Thermal gradient (j/m²/s/C)      +0.04    -0.04
Possible Sun (%)               -0.34    +0.44 *****
Dust Coefficient               +0.02    -0.02
Ground Reflectivity (%)          -0.02    +0.02
Segment Azimuth (degrees)        -0.02    +0.01
West Side:
Topographic Altitude (degrees)   +0.03    -0.04
Vegetation Height (ft)          +0.09    -0.12 *
Vegetation Crown (ft)            +0.07    -0.07 *
```

Vegetation Offset (ft)	-0.04	+0.04	*
Vegetation Density (%)	+0.21	-0.21	**
East Side:			
Topographic Altitude (degrees)	+0.03	-0.02	
Vegetation Height (ft)	+0.11	-0.11	*
Vegetation Crown (ft)	+0.04	-0.04	
Vegetation Offset (ft)	-0.04	+0.04	
Vegetation Density (%)	+0.29	-0.29	***

Scenario 10. Modeling using output from MT411006_030 – Scenario 8 and increase vegetation density in segment MT411006_020 but model only to Sierra Road*

"SSTEMP (2.0.8)"
"NoName"
"English", "Segment Inflow (cfs)", "34.000"
"English", "Inflow Temperature (°F)", "64.100"
"English", "Segment Outflow (cfs)", "37.500"
"English", "Accretion Temp. (°F)", "55.000"
"English", "Latitude (degrees)", "46.700"
"English", "Segment Length (mi)", "2.620"
"English", "Upstream Elevation (ft)", "3705.00"
"English", "Downstream Elevation (ft)", "3680.00"
"English", "Width's A Term (s/ft²)", "14.800"
"English", " B Term where W = A*Q**B", "0.190"
"English", "Manning's n", "0.031"
"English", "Air Temperature (°F)", "78.730"
"English", "Relative Humidity (%)", "32.500"
"English", "Wind Speed (mph)", "7.100"
"English", "Ground Temperature (°F)", "55.000"
"English", "Thermal gradient (j/m²/s/C)", "1.650"
"English", "Possible Sun (%)", "90.000"
"English", "Dust Coefficient", "5.000"
"English", "Ground Reflectivity (%)", "25.000"
"English", "Solar Radiation (Langleys/d)", "630.326"
"English", "Total Shade (%)", "48.156"
"English", "Segment Azimuth (degrees)", "15.000"
"West Side Variables"
"English", "Topographic Altitude (degrees)", "25.000"
"English", "Vegetation Height (ft)", "25.000"
"English", "Vegetation Crown (ft)", "15.000"
"English", "Vegetation Offset (ft)", "5.000"
"English", "Vegetation Density (%)", "75.000"
"East Side Variables"
"English", "Segment Azimuth (degrees)", "15.000"
"English", "Topographic Altitude (degrees)", "35.000"
"English", "Vegetation Height (ft)", "10.000"
"English", "Vegetation Crown (ft)", "5.000"
"English", "Vegetation Offset (ft)", "60.000"
"English", " Maximum Air Temp (°F)", "83.722"
"Dam at Head of Segment","Unchecked"
" Maximum Air Temp (°F)","Unchecked"
"Solar Radiation","Disabled"
"Total Shade","Disabled"
"Month/day","08/07"
"Predicted Mean (°F) = 64.49"
"Estimated Maximum (°F) = 69.64"
"Approximate Minimum (°F) = 59.35"
"Mean Equilibrium (°F) = 68.70"
"Maximum Equilibrium (°F) = 75.73"
"Minimum Equilibrium (°F) = 61.68"

Sensitivity for mean temperature values (10% variation) SSTEMP (2.0.8)
Original mean temperature = 64.49°F
Temperature change (°F)
if variable is:

```
Variable                    Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
Segment Inflow (cfs)            -0.70    +0.73 *****
Inflow Temperature (°F)          -4.25    +4.43 ******************************
Segment Outflow (cfs)           +0.74    -0.79 *****
Accretion Temp. (°F)            -0.43    +0.44 ***
Width's A Term (s/ft²)          -0.16    +0.17 *
  B Term where W = A*Q**B        -0.12    +0.11 *
Manning's n                   +0.00    +0.00
Air Temperature (°F)            -1.46    +1.26 **********
Relative Humidity (%)           -0.22    +0.22 *
Wind Speed (mph)               +0.05    -0.05
Ground Temperature (°F)          -0.07    +0.07
Thermal gradient (j/m²/s/C)      +0.01    -0.01
Possible Sun (%)               -0.07    +0.10 *
Dust Coefficient               +0.01    -0.01
Ground Reflectivity (%)          -0.01    +0.01
Segment Azimuth (degrees)         0.00    +0.00
West Side:
Topographic Altitude (degrees)   +0.01    -0.01
Vegetation Height (ft)          +0.02    -0.03
Vegetation Crown (ft)           +0.02    -0.02
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)           +0.06    -0.06
East Side:
Topographic Altitude (degrees)   +0.01    -0.01
Vegetation Height (ft)          +0.03    -0.03
Vegetation Crown (ft)           +0.01    -0.01
Vegetation Offset (ft)          -0.01    +0.01
Vegetation Density (%)           +0.07    -0.07 *

Sensitivity for maximum temperature values (10% varaition)    SSTEMP (2.0.8)
Original maximum temperature = 69.64°F
                        Temperature change (°F)
                          if variable is:
Variable                    Decreased Increased   Relative Sensitivity
-----------------------------------------------------------------------------
Segment Inflow (cfs)            -0.64    +0.66 *****
Inflow Temperature (°F)          -3.67    +3.82 ******************************
Segment Outflow (cfs)           +0.79    -0.84 *******
Accretion Temp. (°F)            -0.37    +0.38 ***
Width's A Term (s/ft²)          -0.48    +0.51 ****
  B Term where W = A*Q**B        -0.34    +0.33 ***
Manning's n                   +0.17    -0.19 *
Air Temperature (°F)            -1.78    +1.58 **************
Relative Humidity (%)           -0.23    +0.23 **
Wind Speed (mph)               +0.12    -0.13 *
Ground Temperature (°F)          -0.09    +0.09 *
Thermal gradient (j/m²/s/C)      +0.03    -0.03
Possible Sun (%)               -0.31    +0.40 ***
Dust Coefficient               +0.02    -0.02
Ground Reflectivity (%)          -0.02    +0.02
Segment Azimuth (degrees)         -0.01    +0.01
West Side:
Topographic Altitude (degrees)   +0.03    -0.03
Vegetation Height (ft)          +0.09    -0.10 *
```

Vegetation Crown (ft)	+0.06	-0.06
Vegetation Offset (ft)	-0.04	+0.04
Vegetation Density (%)	+0.19	-0.19 **
East Side:		
Topographic Altitude (degrees)	+0.02	-0.02
Vegetation Height (ft)	+0.10	-0.10 *
Vegetation Crown (ft)	+0.04	-0.04
Vegetation Offset (ft)	-0.04	+0.04
Vegetation Density (%)	+0.26	-0.26 **

*** Mixing water equation used to calculate inflow temperature**

Appendix I: Fish Tissue Sampling

(Available Upon Request From Montana DEQ)

Appendix J: MRLC Land Uses

Land Cover Classes:

Water
11 Open Water
12 Perennial Ice/Snow

Developed
21 Low Intensity Residential
22 High Intensity Residential
23 Commercial/Industrial/Transportation

Barren
31 Bare Rock/Sand/Clay
32 Quarries/Strip Mines/Gravel Pits
33 Transitional

Vegetated; Natural Forested Upland
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest

Shrubland
51 Shrubland

Non-natural Woody
61 Orchards/Vineyards/Other

Herbaceous Upland
71 Grasslands/Herbaceous

Herbaceous Planted/Cultivated
81 Pasture/Hay
82 Row Crops
83 Small Grains
84 Fallow
85 Urban/Recreational Grasses

Wetlands
91 Woody Wetlands
92 Emergent Herbaceous Wetlands

Land Cover Classification System Land Cover Class Definitions:

Water - All areas of open water or permanent ice/snow cover.

11. Open Water - areas of open water, generally with less than 25 percent or greater cover of water (per pixel).

12. Perennial Ice/Snow - All areas characterized by year-long cover of ice and/or snow.

Developed - areas characterized by high percentage (approximately 30 percent or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc).

21. Low Intensity Residential - Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.

22. High Intensity Residential - Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.

23. Commercial/Industrial/Transportation - Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.

Barren - Areas characterized by bare rock, gravel, sad, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. Bare Rock/Sand/Clay - Perennially barren areas of bedrock, desert, pavement, scarps, talus, slides, volcanic material, glacial debris, and other accumulations of earthen material.

32. Quarries/Strip Mines/Gravel Pits - Areas of extractive mining activities with significant surface expression.

33. Transitional - Areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.)

Forested Upland - Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); Tree canopy accounts for 25-100 percent of the cover.

41. Deciduous Forest - Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest - Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest - Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrubland - Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. Shrubland - Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases when the cover of other life forms
(e.g. herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms.

Non-natural Woody - Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25-100 percent of the cover. The non-natural woody classification is subject to the availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

61. Orchards/Vineyards/Other - Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland - Upland areas characterized by natural or semi- natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.

71. Grasslands/Herbaceous - Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

Planted/Cultivated - Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75-100 percent of the cover.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops - Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains - Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.

84. Fallow - Areas used for the production of crops that are temporarily barren or with sparse vegetative cover as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.

85. Urban/Recreational Grasses - Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Wetlands - Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. Woody Wetlands - Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Appendix K: Supplemental Data
(Available Upon Request from DEQ)